World Class Manufacturing

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Part I : Introduction

1. Importance of Continuous Improvement
2. What is WCM and Why WCM now?
3. TQC, TQM, TPM, JIT, and TIE
4. Importance of Cost Deployment
5. 7 Steps to WCM — Priorities
6. Major Pillars to Support WCM
7. 10 Management Evaluation Criteria
   and 10 Pillar Evaluation Criteria

1. Importance of Continuous Improvement

1.1 Importance of Continuous Improvement

1.2 The Reality of Innovations without Kaizen and with Kaizen

1.3 Philosophical Differences

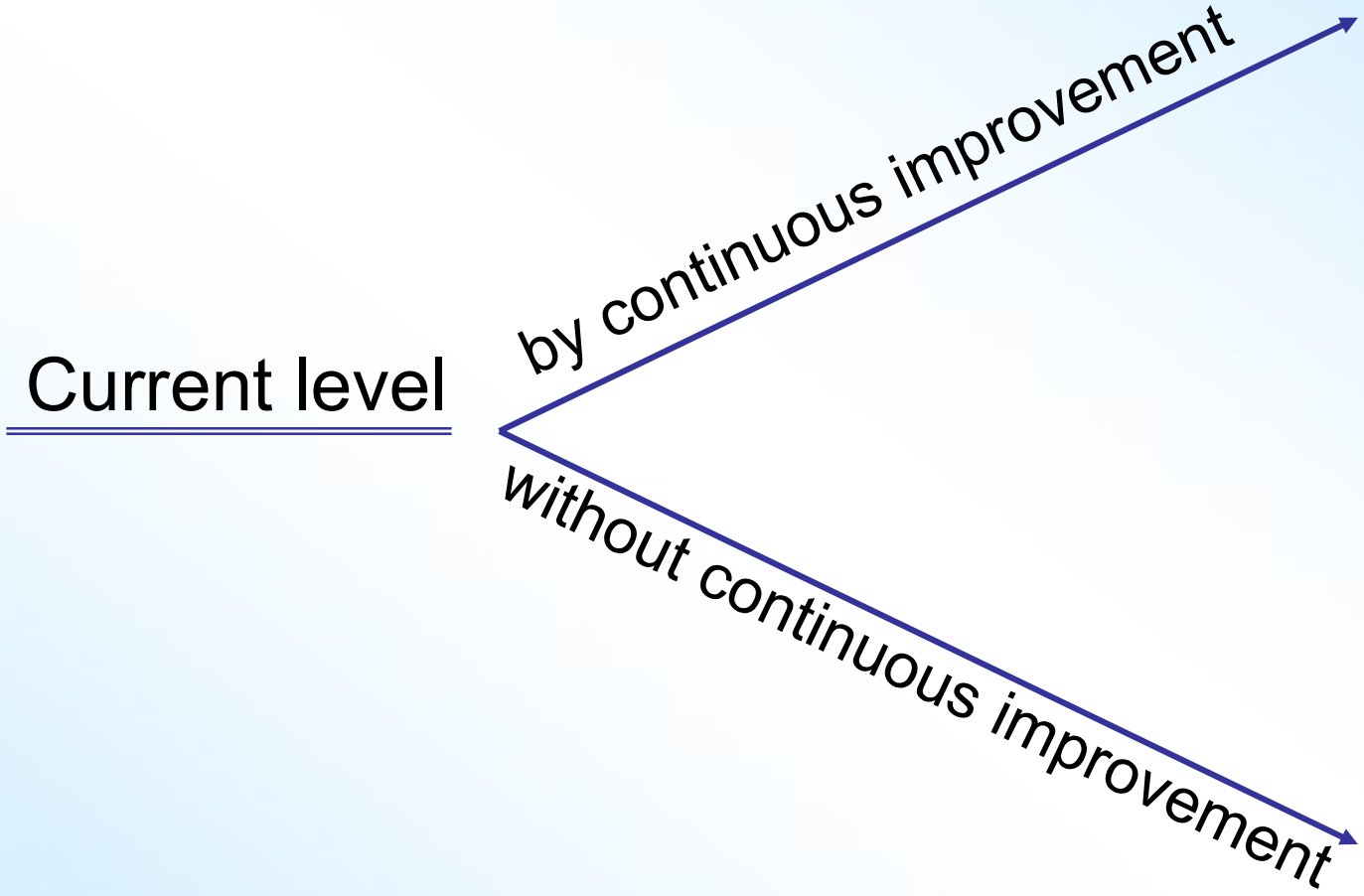
1.4 Two different approaches

1.5 The need of continuous improvement on the production floor

1.6 Commitment of the organization

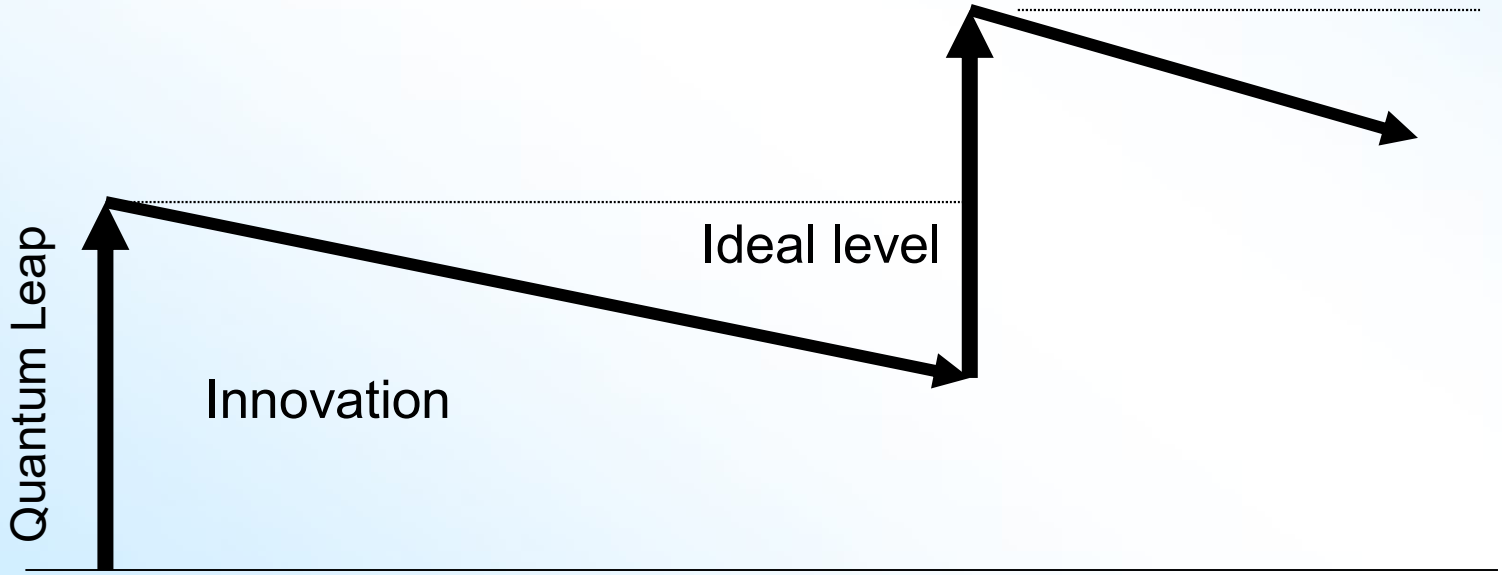
1.7 Metaphors and Manuals

Importance of Continuous Improvement

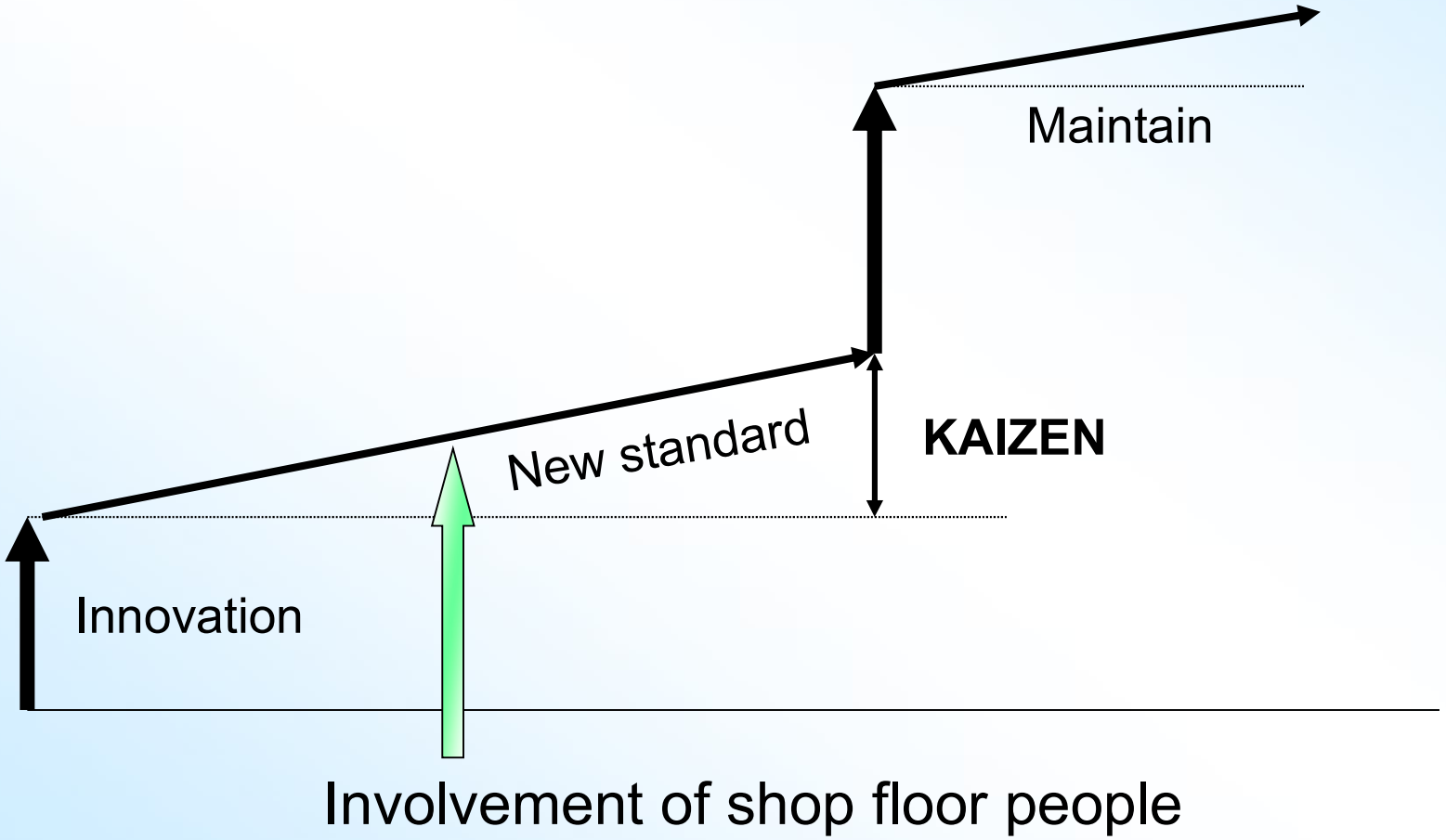


The Reality of Innovation without Kaizen

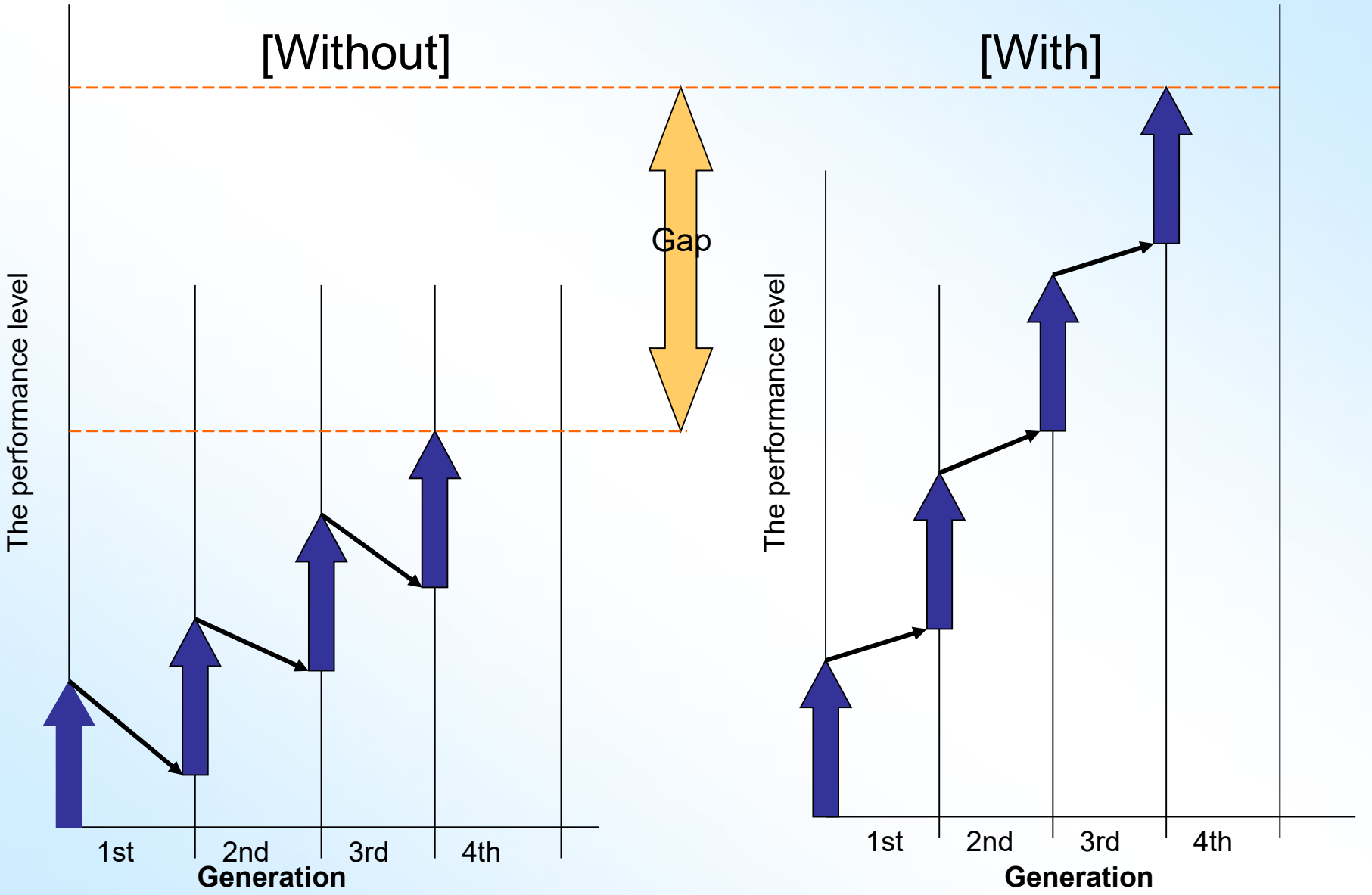
- Importance of Continuous Improvement



Innovation with Kaizen



Two cases without continuous improvement and with continuous improvement

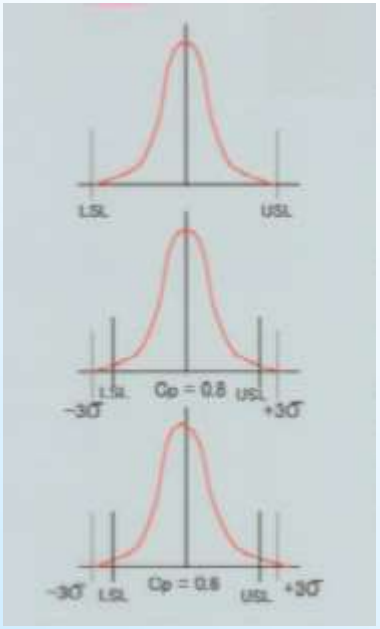


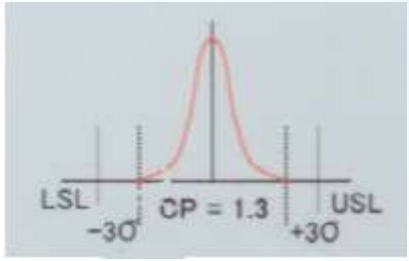
Philosophical Differences

Failure Driven

Process is capable

move to the next fire





"if it ain't broke, don't fix it"

"KAIZEN"

6 months later

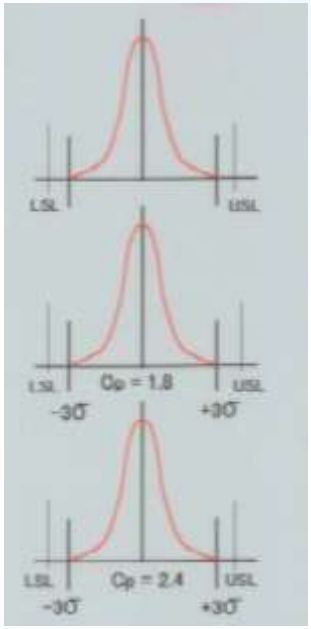
12 months later

24 months later

Prevention Driven

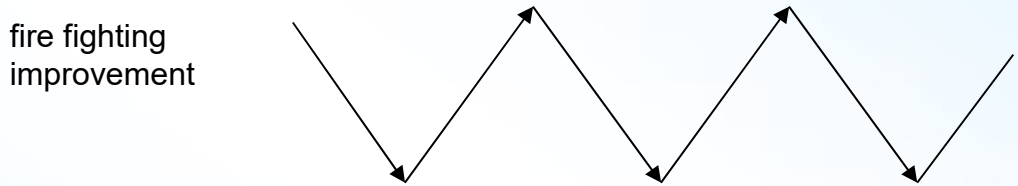
Process is capable

only the starting point



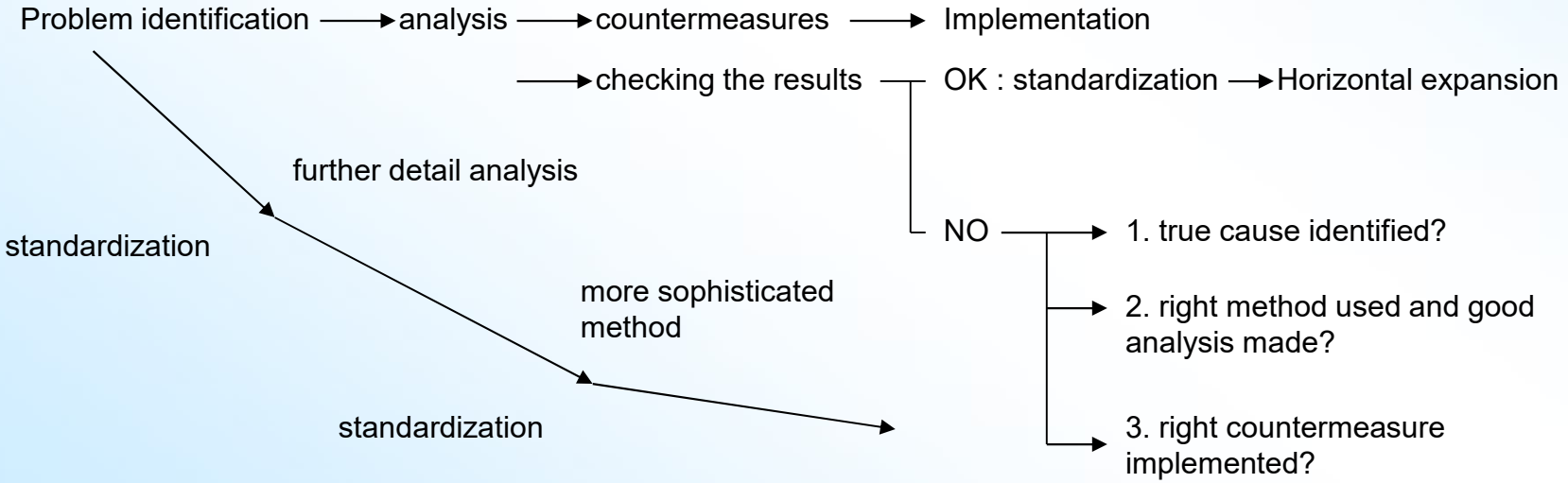
Two different approaches

1) Fire fighting approach



Due to lack of foundation
and lack of standardization and maintenance, sustaining the achieved result is difficult
and the problem will come back again.

2) Continuous improvements with P.D.C.A cycle
– Build from fundamentals, lasting progress



The need of continuous improvement on the production floor

Problems	Countermeasure
Bad design	Development of competent production engineers and able operators who can cope with the problems
Maintenance	
Market change	
New technology	

In a factory, there normally exist huge amount of waste and losses such as the following :

(1) Machine breakdowns

(2) Setup operation

(3) Defectives

(4) Minor stoppages

(5) Delay of part delivery from suppliers

(6) Absence of an operator

⋮

which will just increase production cost.

Unless we are able to highlight these problems visually and resolve them quickly enough, production becomes weaker and weaker and will harm the company eventually.

Commitment of the organization

The five levels of active organization :

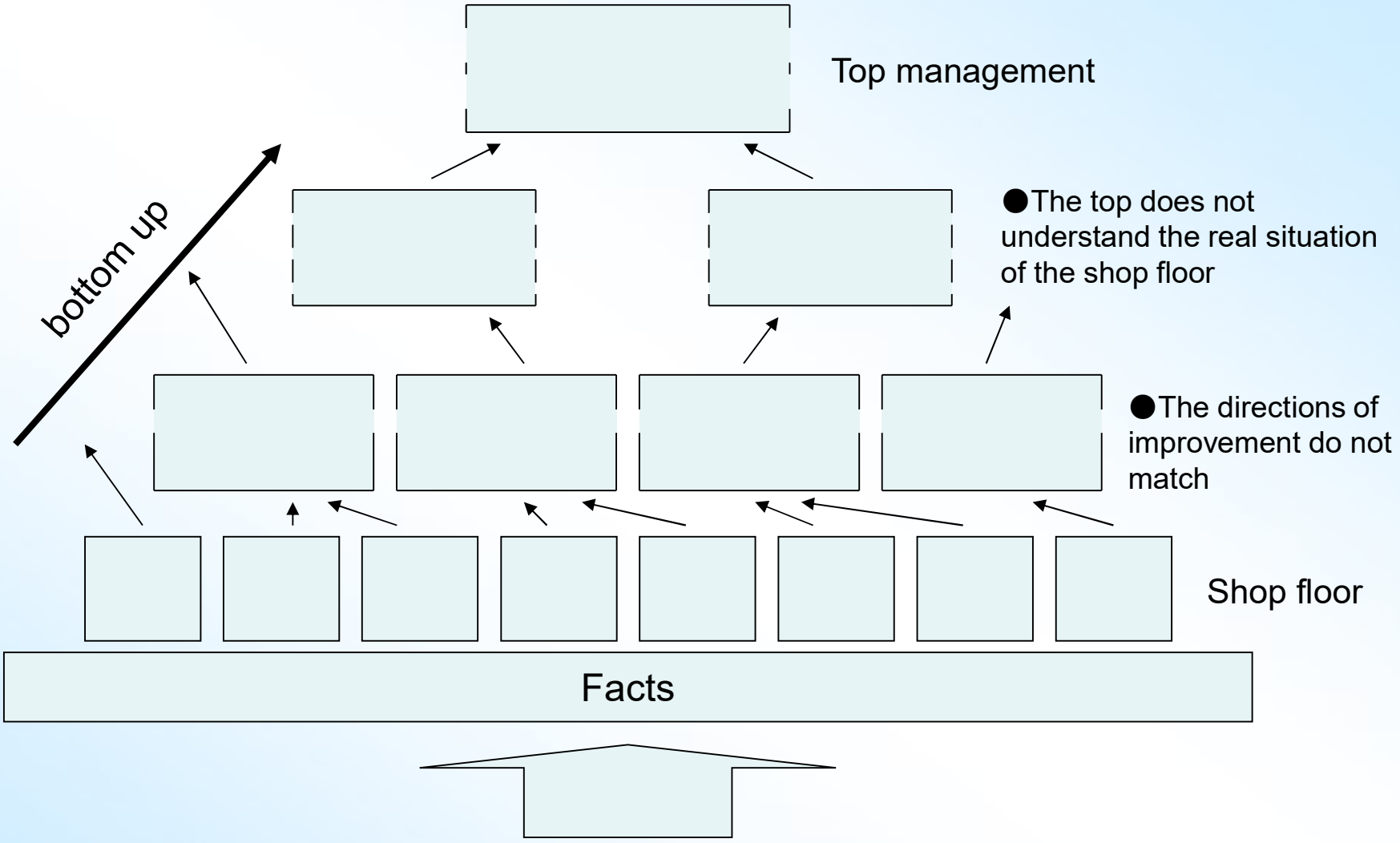
Level 1 : People deny that there are problems or don't want to see them.

Level 2 : People admit that there are problems but find excuses for not being able to solve them.

Level 3 : People accept the fact that there are problems but unable to solve them because they don't know how to attack them.

Level 4 : People want to see potential problems and for this try to visualize them. They will attack them by learning proper methods.

Level 5 : People know their problems, methods to solve them and how to involve all the people to attack them. They are ready to attack any problem and to change their organization if needed after solving the problem.



Tactics oriented, local optimum seeking

Fig. The Japanese way

Strategy oriented, overall optimum seeking

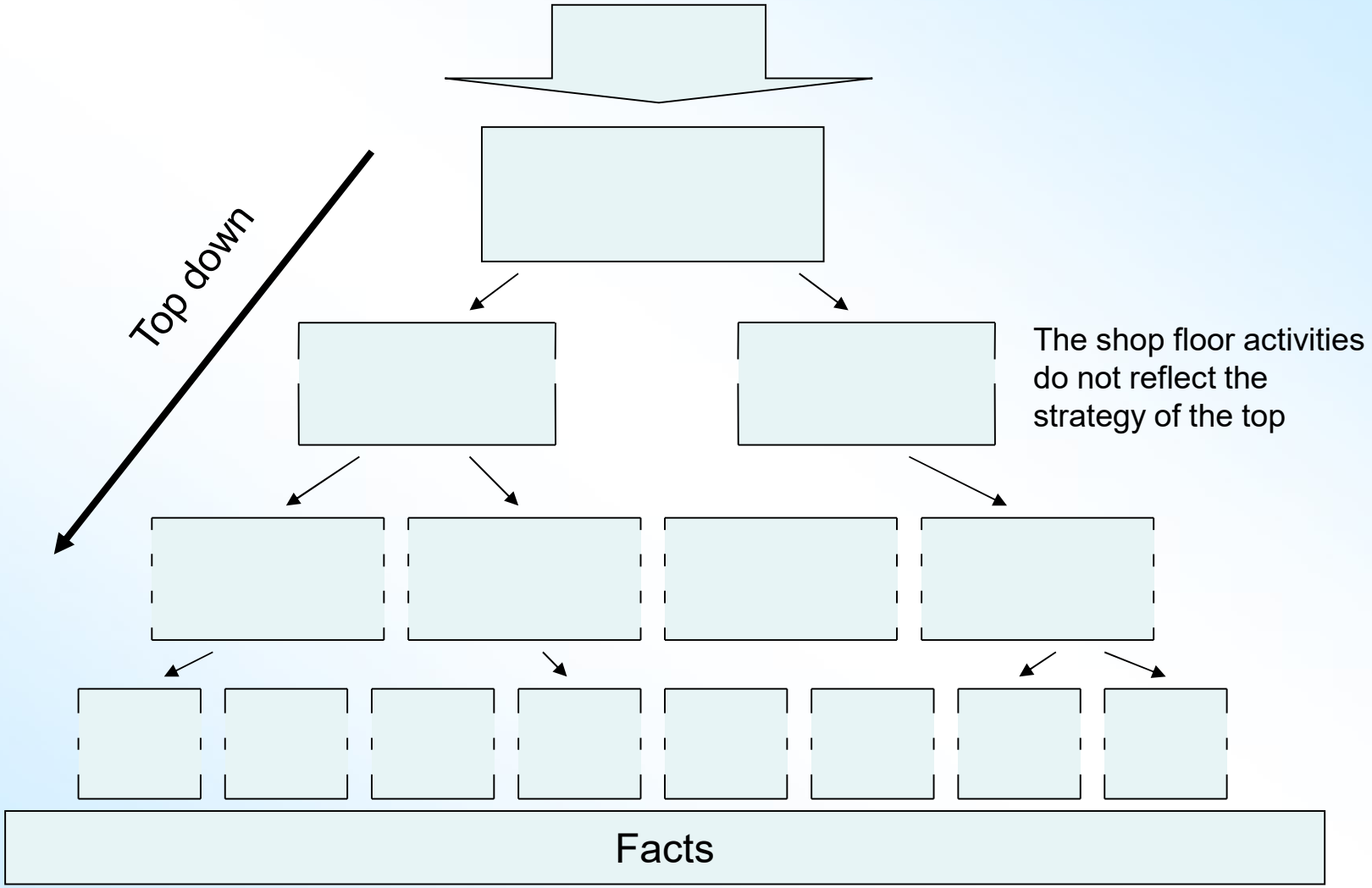


Fig. The American and European ways

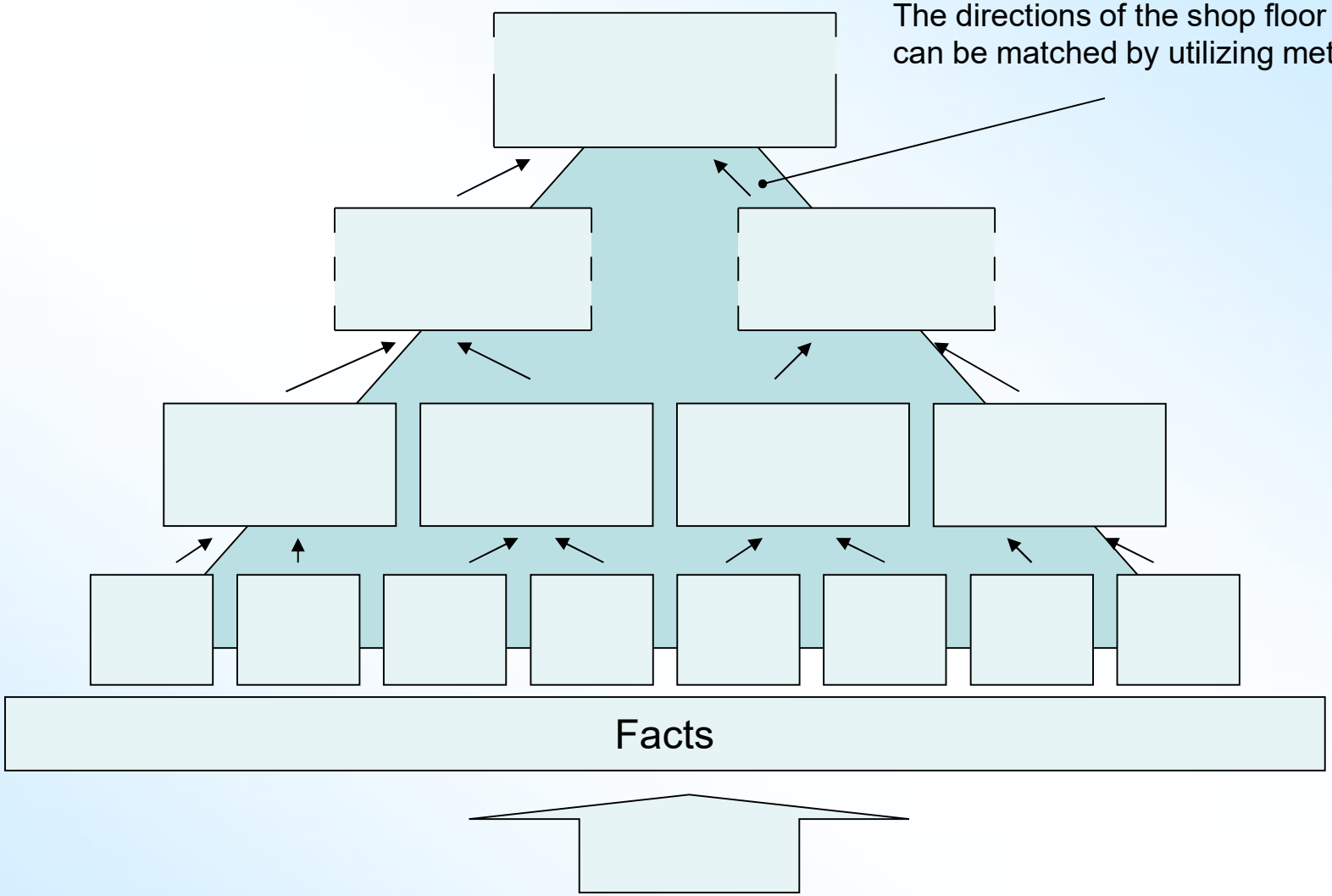


Fig. To direct the shop floor activities needs metaphors

Strategy oriented + Manuals

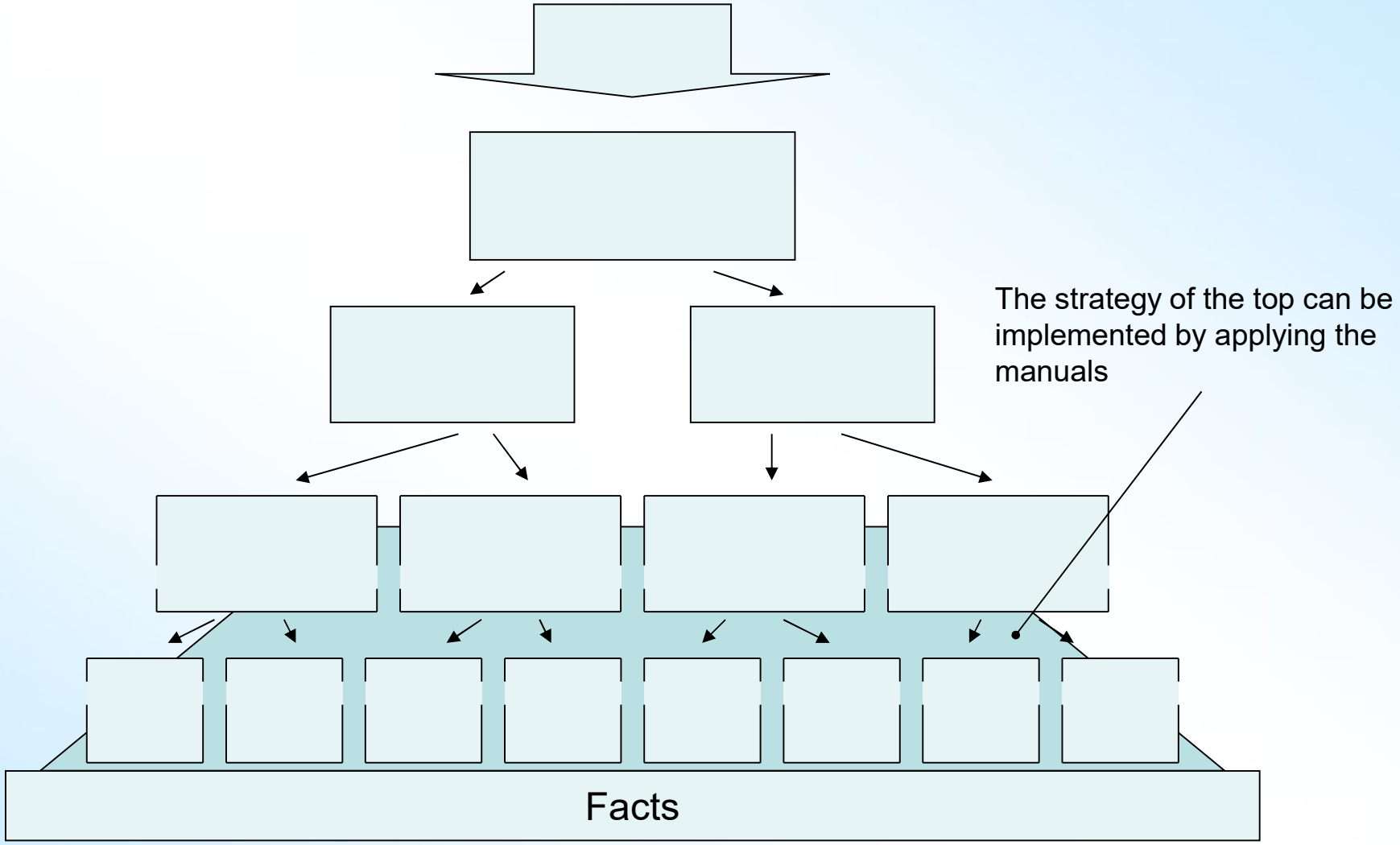


Fig. To implement the strategy fully needs manuals

Level 1

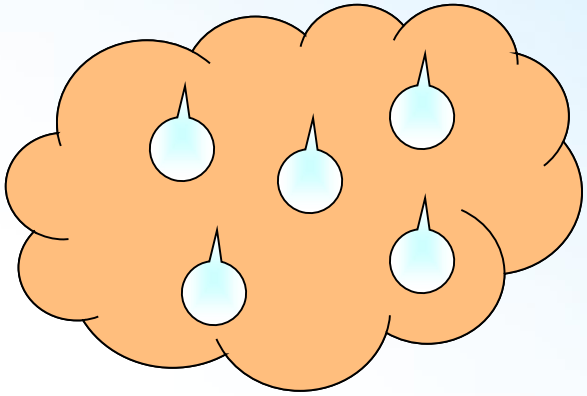
A drop of water

Water

Physical characters of water

Level 5

A collection of drops of water



Cloud

Completely different behavior
from physical characters of water

To improve cash flow, production performance is very, very important.

But, it varies very much depending on the nation, the company, the corporate culture, the factory and the employees even if they use the same equipment.

Unless we in production continuously find our problems by ourselves and set our themes to resolve autonomously, the company will not become competitive enough to fight in a fierce and highly competitive market.

Plant manager

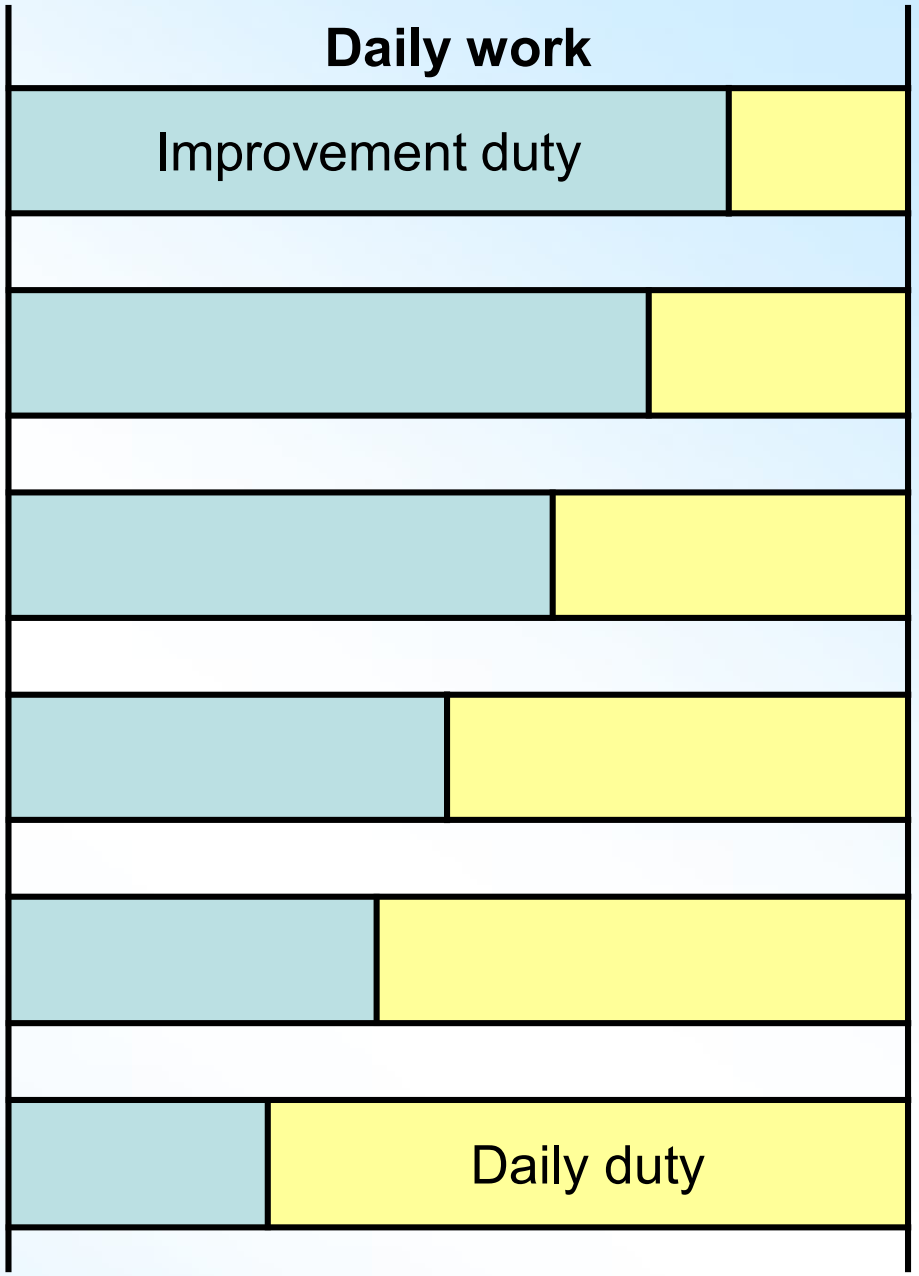
Head of department

Head of section

Assistant manager

Foreman

Worker



On hierarchic organization, people in the upper rank must have higher percentage of improvement duties.

Maintaining the present state is a vice that refuses improvement.

Only changes create improvement.

- Various management tools such as :
  1. Lean (or agile) production
  2. 6 σway
  3. Kaizen (Continuous Improvement)
  4. Empowerment of people
  5. Concurrent engineering

were developed by Americans.

- These were developed by careful study of Japanese manufacturing, especially JIT system.
- They found the strength of it is the one of “process” and the one of empowered shop floor people.

"It is not the strongest of the species that survives,
not the most intelligent,
but the one most responsive to change."

Charles Darwin / The Origin of the Species

2. What is WCM and Why WCM now?

2.1 What is WCM and why WCM now?

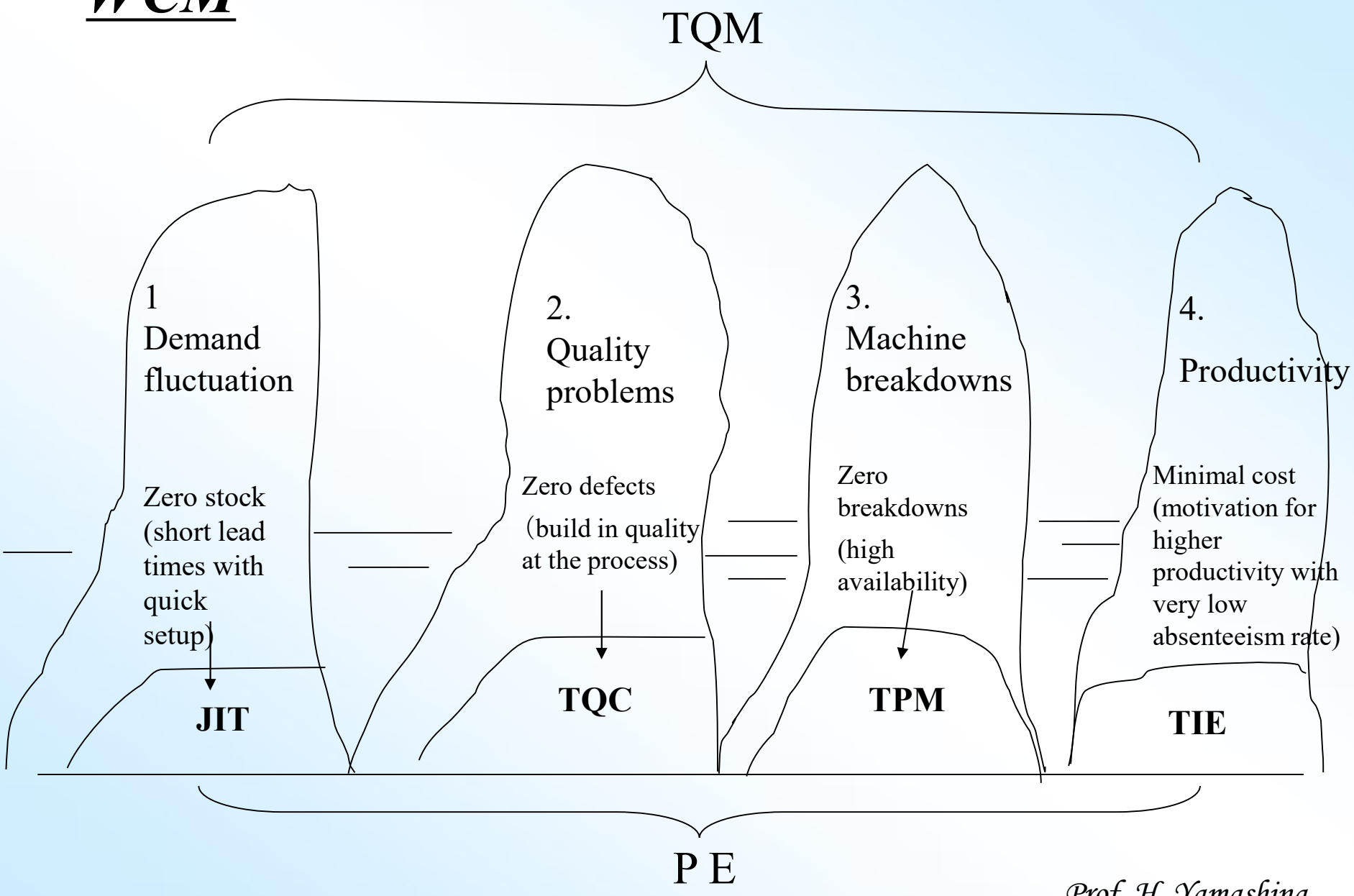
2.2 WCM

What is WCM and why WCM now?

WCM is a comprehensive system for improving productivity, reducing breakdowns and improving quality by involving all employees in the wasted time and resources caused by sub-standard reliability and operating performance of the production system. The power of WCM comes from the employee involvement teams.

To produce good products, we must have good people and involve them for continuous improvement.

WCM


TQM
1
Demand
fluctuation
Zero stock
(short lead
times with
quick
setup)
JIT
2.
Quality
problems
Zero defects
(build in quality
at the process)
TQC
3.
Machine
breakdowns
Zero
breakdowns
(high
availability)
TPM
4.
Productivity
Minimal cost
(motivation for
higher
productivity with
very low
absenteeism rate)
TIE
P E

WCM

Japanese WCM involving TQC, TPM, TIE and JIT under the umbrella of TQM is a practical way of providing sustainable benefits

WCM requires TQM as the brain, JIT as the nerve system and TPM as the muscles. The core of WCM is TQM. Without TQM, WCM cannot be materialized.

TQM

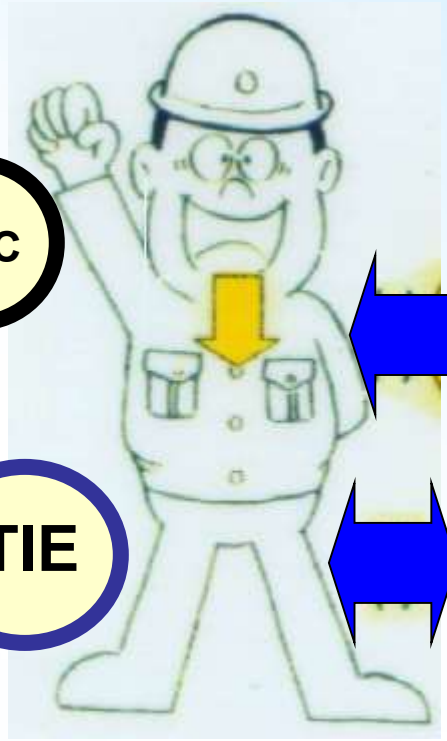
SOFTWARE

- METHOD

TQM

Change intangible software into hardware and humanware

TQC



JIT

TPM

HARDWARE

- MACHINE
- MATERIAL

TIE

TPM

TIE

HUMANWARE

P T

3. TQC and TQM

3.1 The definition of TQC and TQM:

3.2 Development of the Japanese Quality Assurance

3.3 Investigation of process capability

The definition of TQC and TQM

- A system of means whereby the qualities of products or services are produced economically to meet the requirements of the purchaser.
- “Quality control” is sometimes called “QC”for short. In addition, since modern quality control adopts statistical techniques, it is sometimes called “statistical quality control”, and “SQC” for short.

The definition of TQC and TQM

- In order to perform quality control effectively, throughout all phases of the enterprise activities such as market survey, research and development, planning of product, design, production readiness, procurement and subcontract, manufacture, inspection, sales and after sales servicing as well as finance, personal affairs and education and training, whole personnel including from the executives down to the managers, foremen and workers are required to participate and collaborate.
- The quality control activities conducted in such way is called “company-wide quality management” or “total quality management”, and “TQM” for short.

The QC Mindset : *The QC viewpoint is vital*

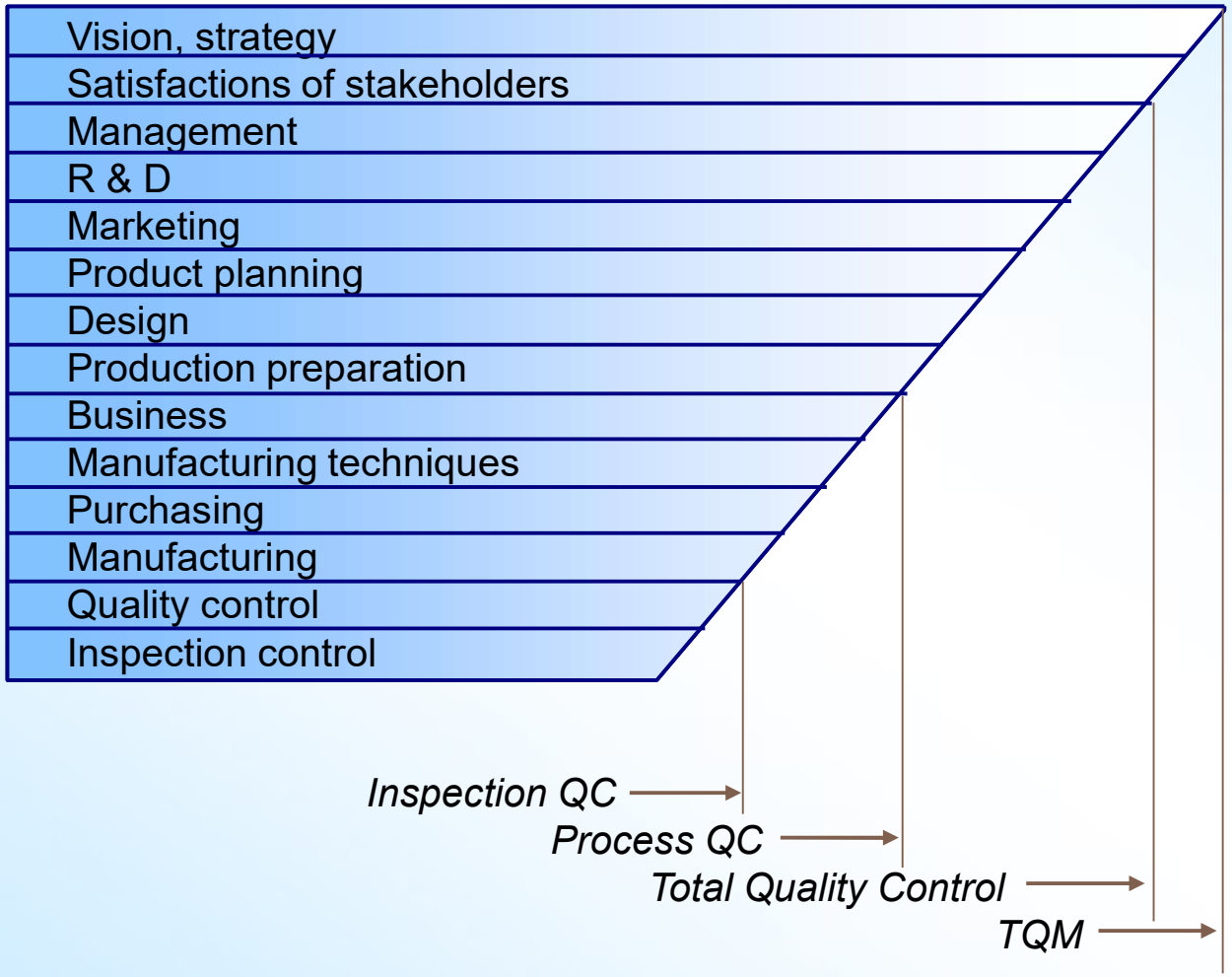
Tab. 3.1 Traditional Way of Thinking

Traditional Way of Thinking	***QC Viewpoints***
1. Product out * I am always right. * I decide with my own judgment even if I may have prejudice. * I cannot be frank.	1. Market - in * I think from the viewpoint of the customer. * I am humble enough to accept other people's opinions.
2. Dependence of my own knowledge * I depend on my tuition and experiences.	2. Dependence of the fact * I carefully evaluate based on the observation of the fact.
3. Results oriented * Countermeasures are taken only against phenomena. * Only plan and no doing.	3. Procedures are as important as results. * The relationships between causes and effects are pursued. * PDCA cycles are run to get things done.

Tab. 3.1 Traditional Way of Thinking *(- continued)* ***(-Continued)***

Traditional Way of Thinking	***QC Viewpoints***
4. Simple thinking *** Differences are ignored.** *** Things are regarded as similar.** *** Things are treated in an abstract way.**	**4. Paying attention to dispersion and identification of its causes** *** Differences are appreciated.** ***The proper procedure based on dispersion is used.** *** Things are treated in a concrete way.**
5. Excuses for not being able to do *** Without trials, a conclusion is drawn.** *** Discussions are made based on assumptions.**	**5. Devices to solve the problems** *** Anything cannot be understood without being tried.** *** Discussions are made based on the accumulation of the facts.**
6. Fire-fighting approach	**6. Recurrence prevention approach**
7. Sentimental discussions	**7. Logical discussions**

Development of the Japanese Quality Assurance



Tab. 3.3 The QC Mindset

Category		The QC Mindset	Meaning
T	Total	(1) Strengthening the company constitution	Use QC to create a company constitution capable of achieving lasting prosperity
		(2) **Total participative** management	Unite employees' talents companywide and exercise them to the full
		(3) Education and dissemination	Boost human resource development by strengthening education and training
		(4) QC audits	Top management itself must check the state of progress of QC and champion QC activities
		(5) Respect for humanity	Respect people's dignity and have them do their best
S	Statistical	(6) Use of QC tools	It's no good trying to do things by one's own devices
		(7) **Dispersion** control	Pay attention to dispersion and identify its causes

Tab. 3.3 The QC Mindset (*-continued)*

Category		The QC Mindset	Meaning
Q	Quality	(8) Quality first	Aim to secure profits by giving top priority to quality
		(9) Customer orientation	Make the goods and services that customers really want
		(10) **The next process is your customer**	Never send defectives or mistakes on to the next process
C	Control	(11) The PDCA Wheel	Conscientiously follow the Deming Cycle
		(12) Management by fact	Base decisions and actions on facts
		(13) **Process control**	Control the process of work rather than its results
		(14) **Standardization**	Formulate, observe and utilize standards
		(15) Source control	Control systems at their source, not downstream
		(16) **Policy management**	**Use policy management to evolve consistent company activities**

Tab. 3.3 The QC Mindset (*-continued)*

Category		The QC Mindset	Meaning
C	Control	(17) Cross-functional management	Create horizontal links throughout the organization and improve systems for managing quality, cost, delivery, safety and morale
I	Improvement	(18) Priority consciousness	Pounce on priority problems and attack them mercilessly
		(19) **The QC 7-Step Formula**	Effect improvements by faithfully following the QC 7-Step Formula
		(20) **Recurrence prevention**, prior prevention	**Never repeat the same mistake!** Do not neglect recurrence prevention and prior prevention of trouble

Quality Specifications and Tolerances

• The quality we want to improve and control is concretely represented by figures showing length, hardness, percentage of defectives, etc. They can be called quality characteristics.

• There are various factors such as chemical composition, diameters, workers, etc. which can cause the dispersion of the figures.

• Thus, the requirement of a quality characteristic is given, by a specific value with its tolerance.

• There are two categories of values :

** Indiscrete (or continuous) values based on measurements

eg. 1 yields of a chemical process

2 board weight

** Discrete (or enumerated) values based on counting

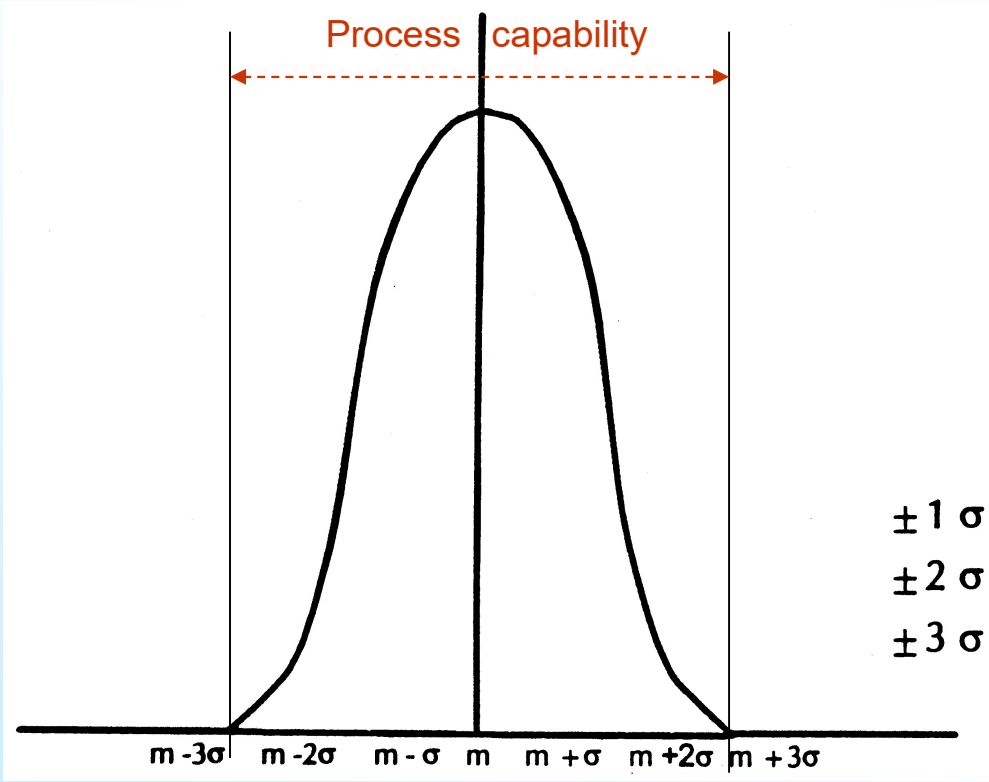
eg. 1 defective articles or the number of defects

2 blisters

3 cocklings

If the quality characteristic is assumed to follow a normal distribution, where ±3σ includes 99.73 percent of the population, process capability is defined in the following way :

Process capability = ±3σ or 6σ



$$f(x) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-\frac{1}{2}\left(\frac{x-m}{\sigma}\right)^2}$$

±1 σ contains the probability of 68,26 (%)
±2 σ contains the probability of 95,46 (%)
±3 σ contains the probability of 99,73 (%)

Fig. Normal distribution

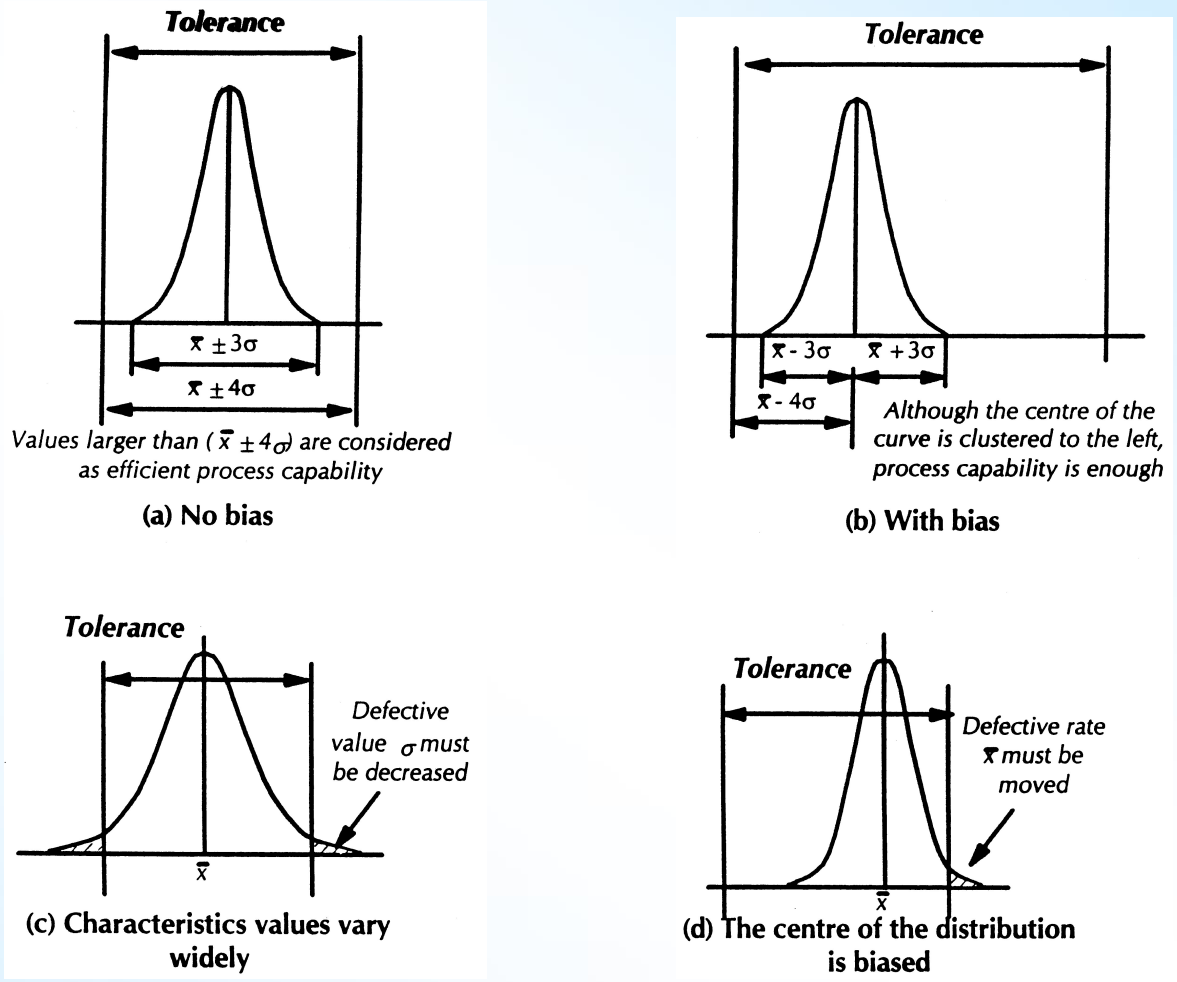


Fig. Relationship between characteristic distribution and tolerances (standard value)

While, process capability index can be calculated as follows :

Case (a) : Two-sided, upper and lower limits of standard

$$Cp = (ut - lt) / 6\sigma$$

Case (b) : One-sided, upper limit of standard

$$Cp = (ut - \bar{x}) / 3\sigma$$

Case (c) : One-sided, lower limit of standard

$$Cp = (\bar{x} - lt) / 3\sigma$$

where, ut : upper tolerance limit

lt : lower tolerance limit

$\bar{x}$: the mean value of the distribution

In case where x deviates from the target value, the following C_{pk}

should be used :

$$Cpk = (1 - k)(ut - lt) / 6\sigma$$

where, k : the degree of deviation

$$= \frac{(ut + lt) / 2 - \bar{x}}{(ut - lt) / 2}$$

If $k > 1$, let $Cpk = 0$

Process capability = machine capability

Process capability = machine capability (Cmk changes over time)

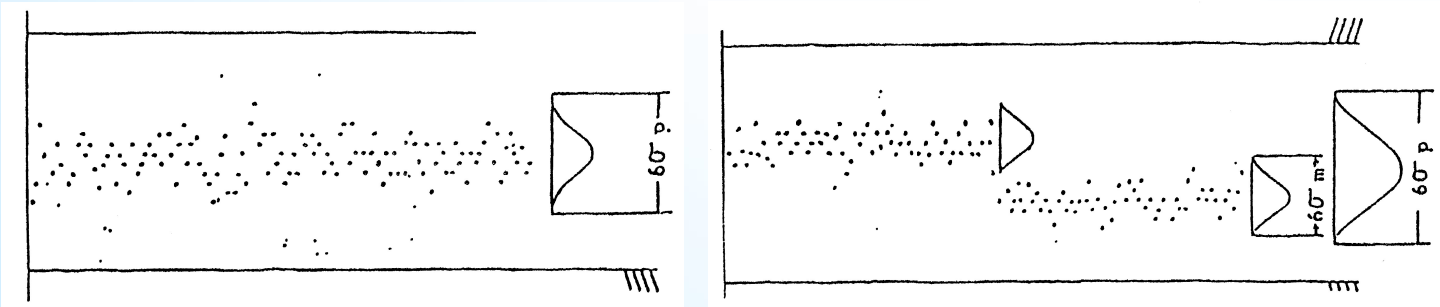


Fig. C_p and C_{pk}

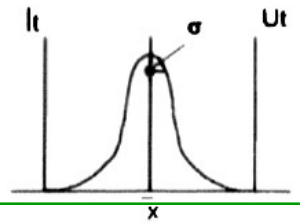
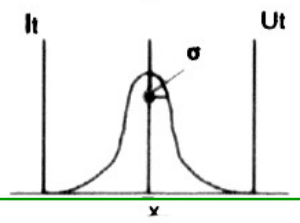
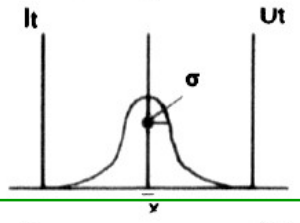
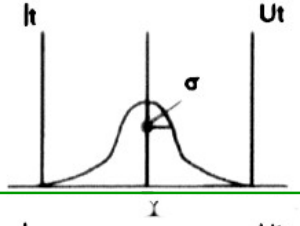
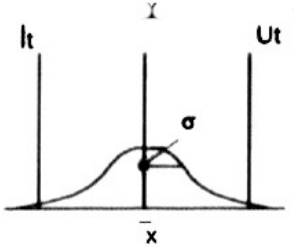
Cp	Distribution	Judgment	Action
Cp ≥1.67		Process capability is more than enough.	Simplification of process control and cost reduction can be considered in certain cases.
1.67 > Cp ≥1.33		Process capability is sufficiently high.	Ideal condition. Maintain it.
1.33 > Cp ≥1.00		Process capability is not sufficiently high, but is adequate.	Control process properly and maintain it in a control state. Defects may result if Cp approaches 1. Take action if needed.
1.00 > Cp≥ 0.67		Process capability is not sufficient.	Defects have been generated. Screening inspection and process. control and Kaizen will be required.
0.67 > Cp		Process capability is vary low.	Cannot satisfy quality. Quality must be improved, cause must be pursued and emergency actions must be taken. Reexamine standards.

Fig. Judgment on the process based on the value of Cp

Remember that

If $C_p \ll 1$, the process is not capable to produce products properly.

If $C_p = 1$, 27 items out of 10,000items are out of tolerances.

If $C_p \geq \frac{4}{3}$ About 64 items out of 1,000,000 items are out of tolerances. With this low level of defective production, the process can be managed.

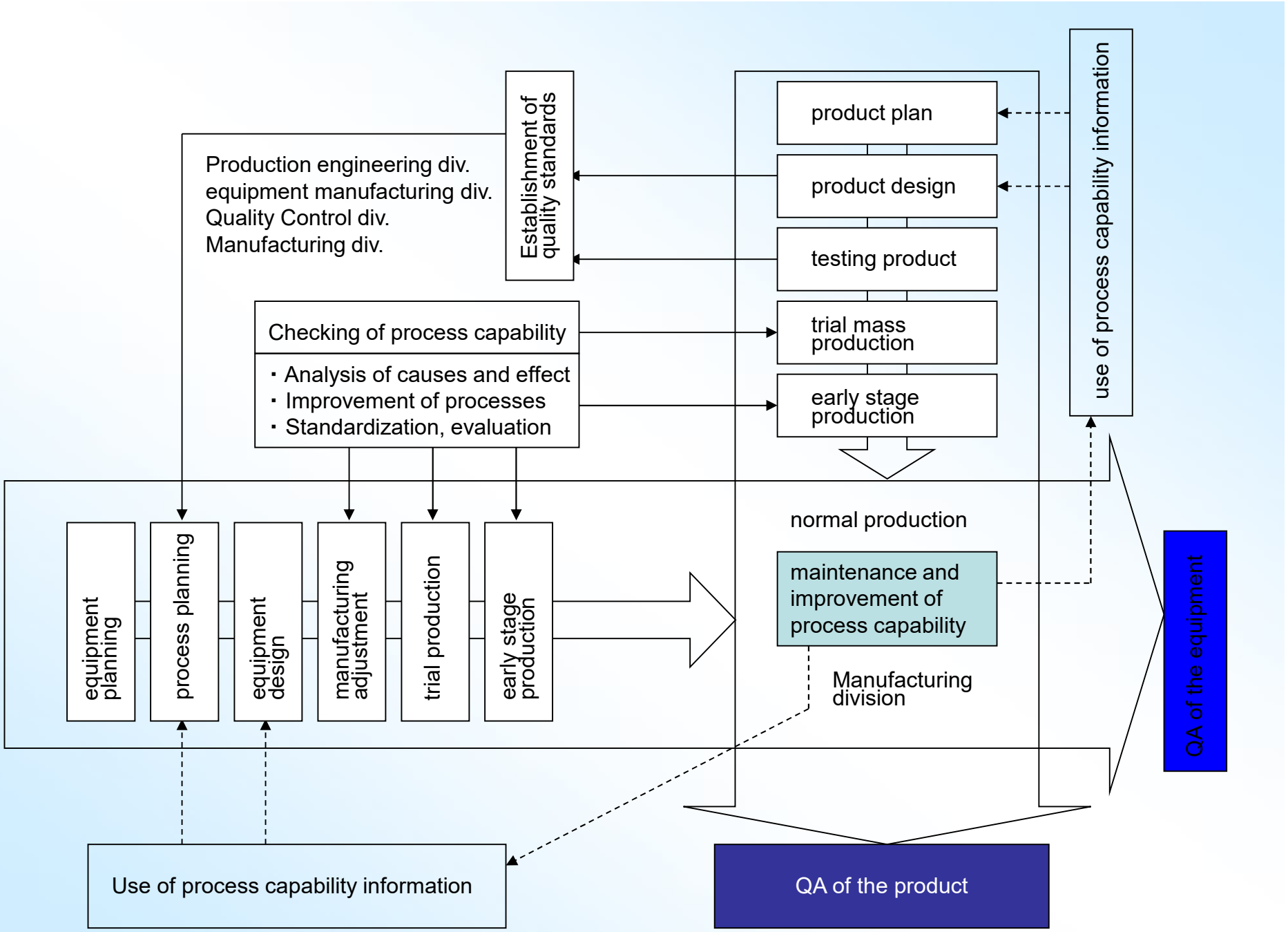
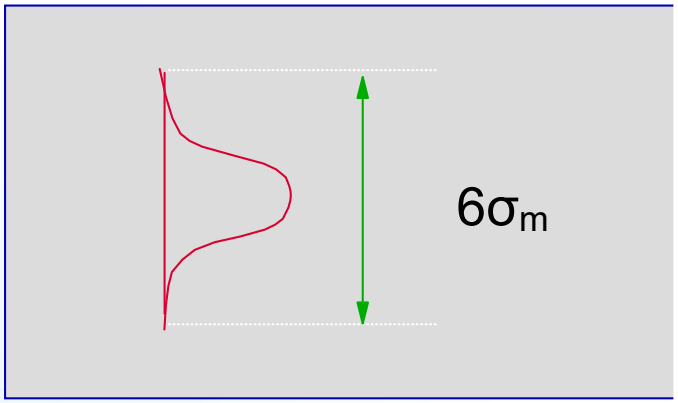
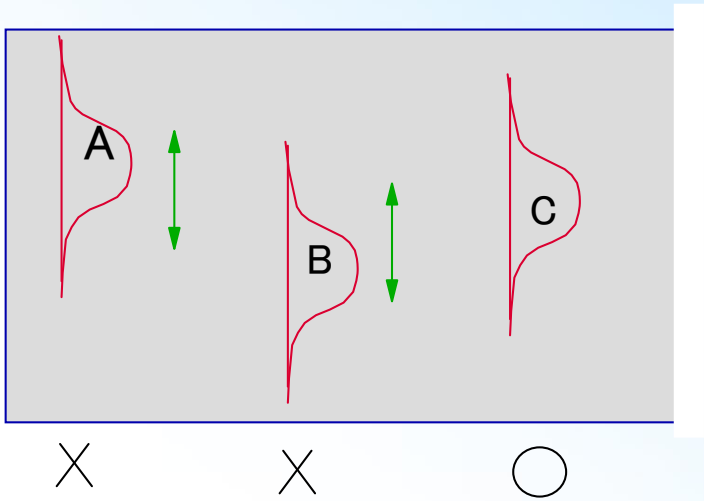


Fig. The structure of process capability checking



Develop equipment endowed with high process capability

(a) Design engineers



Control the variation's middle value

(b) Production site

Fig. The role of design engineers and operators

Which is easier to control quality, 6σway or TQM way ?

	6σway	TQM way
Required process capability	6σ≦0.5T	6σ≦0.75T
Required activity on the shopfloor		Quality maintenance
Production engineer	involved	involved
Operator	?	involved
Result	3.4 ppm	Ca 64 ppm

σ: standard deviation
6σ: process capability
T : Tolerance width= USL – LSL

accurate launching

adjustment
(trial and error)

The tools developed in TQM philosophy

- QC 7 tools, SQC,
- New QC 7 tools
  - * Relations diagram
  - * KJ method (affinity diagram)
  - * Systematic diagram
  - * Matrix diagram
  - * Matrix data analysis
  - * Process decision program chart (PDPC)
  - * Arrow diagram
- 7 tools for product planning
- 7 tools for establishing strategy
- Policy management
  . . . Policy deployment
- QFD
- Process FMEA
- FTA
- DR system
- Reliability engineering, etc.

4. TPM

4.1 Definition of TPM (Company-Wide TPM)
4.2 5 Key Points to Solve the Problems
4.3 What TPM Aims at
4.4 TQM and TPM
4.5 The tools developed in TPM philosophy

Definition of TPM (Company-Wide TPM)

TPM aims at:

- Pursuing “zero”targets as “zero-accidents”,”zero-defects” and ”zero breakdowns” in the entire production system life by organizing management system based on 5G principles,
- Involving every member of the organization, from top management to shop-floor operators,
- Integrating all functions of the organization including production, development--- and even sales,
- Educating and training every member, and raising his or her capability, and
- Establishing corporate culture that will meet the society needs.

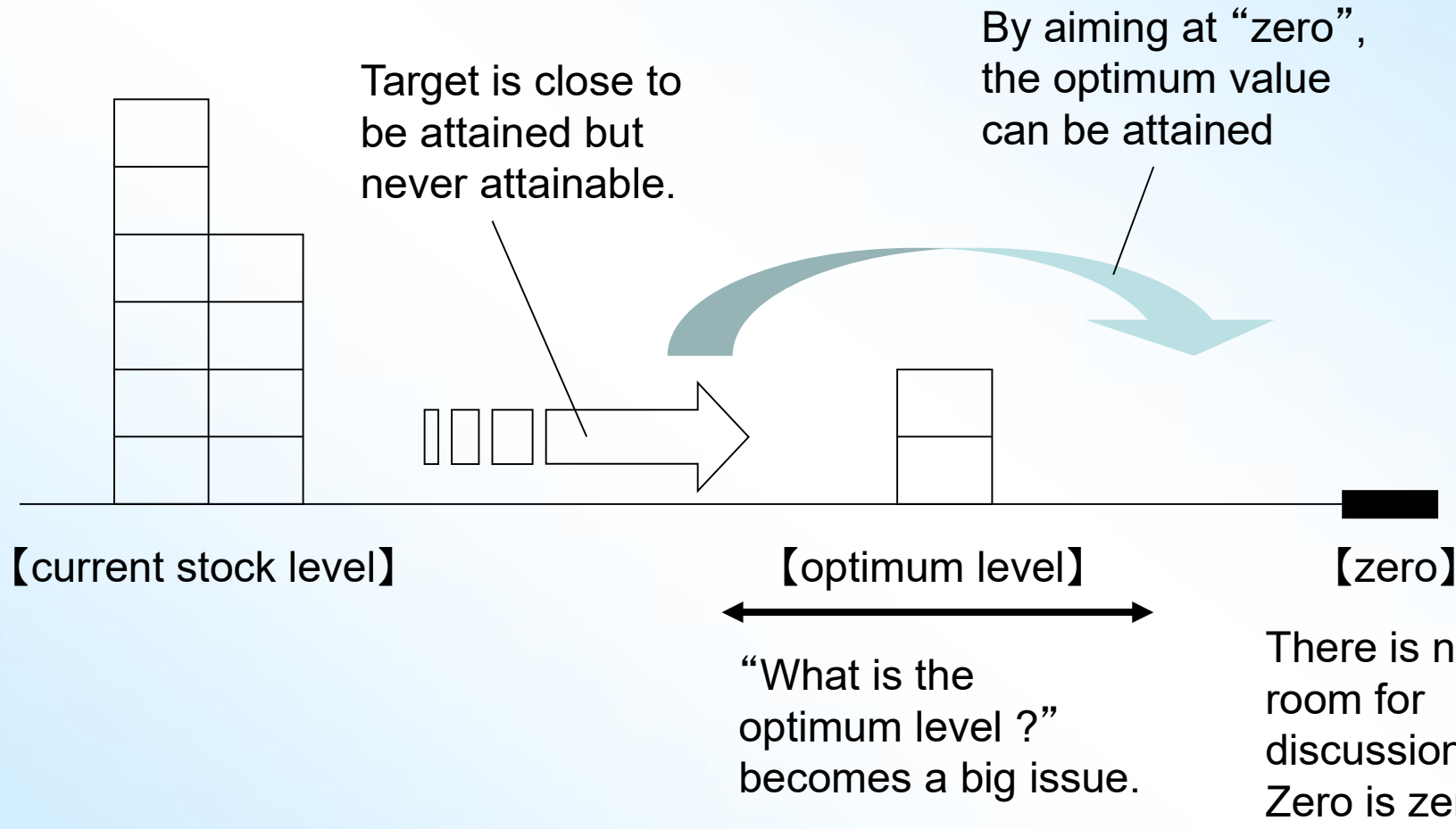


Fig. Meaning of targeting Zero

5 Key Points to Solve the Problems

GEMBA	→	Go to the spot
GEMBUTSU	→	Examine the object
GENGITSU	→	Check facts and figures
GENRI	→	Refer to the theory
GENSOKU	→	Follow the operating standard

Go to the spot	The workplace, the place where event actually happens
Examine the object	The 'phenomenon' (what actually happened, what you can actually observe with your own eyes, without any preconceived ideas about it)
Check facts & figures	The actual equipment, materials, products and other physical objects actually involved in an event
Refer to the theory	Principles (physical and or chemical)
Follow Op Standards	Standards & Parameters (physical values)

What TPM Aims at

To restructure the corporate culture through improvement of human resources and plant equipment

Improving human resources

- Educate and foster employees so that they can cope with the company needs

(1) Operators : Ability to perform " Autonomous maintenance "
(2) Maintenance people : Ability to perform first class professional maintenance
(3) Production engineers : Ability to develop highly effective equipment

Improving plant equipment

(1) Attain effectiveness through correction of the existing equipment
(2) LCC-considered design of new equipment and minimizing their startup time

Improving the corporate culture

TQM and TPM

Category	TQM	TPM
Purpose	Improvement of corporate culture (Improvement in actual performance,Creating a cheerful working environment)	
Object	Quality (Output side, Effect)	Equipment (Input side,Cause)
Means to achieve the end	Systematize the management (Systematization / Standardization) - Software oriented -	Realization of ideal production operation -Hardware oriented-
Cultivation and education of employees	Education focusing mainly on the management technique (QC technique)	Education centering on the (Equipment / maintenance technologies)
Small group activities	Voluntary circle activities	Integrating the activities based on job description and by small group circle
Target	Quality for PPM order	Though elimination of losses and wastes (Aiming at achievement of zero loss)

The tools developed in TPM philosophy

- 5S
- Autonomous Maintenance
- Planned Maintenance
- 5 Why analysis
- 5G Principles
- Step by step approach
- Processing point analysis, etc.

5. JIT

5.1 The definition of JIT production:

5.2 Two Performance Measures

5.3 The tools developed in JIT philosophy

5.4 Mixed delivery

5.5 Delivery per item

The definition of JIT production

- It means a total production system which emphasizes producing exactly what is needed and conveying it to where it is needed precisely when required.
- The goal of JIT production is to find practical maps to create the effect of an autonomated industry which will come as close as possible to this concept of ideal production.

JIT (Lean Production)

Characteristics:

- Leveled production
  - -One piece flow
  - -Single set up
- Just-in-time
  - -Kanban
  - -Quality assurance at the process
  - -Utilization of manual idle time
  - -Multi-purpose operation

JIT makes it possible to
- -pose problems and promote improvement
- -utilize and foster people, and
- -reduce the amount of man-hours of indirect operation

Conventional Mass Production

Characteristics:

- Large lot production
  - -Large warehouses, large inventory
  - -Production system for each product (concentration)
- Job division system
  - -Machining division, assembly division
  - -Inspection division
  - -Production control division

Based on the theoretical calculation on the statistical data, conventional mass production is liable to
- -ignore human nature (man is a part of a machine) and
- -deteriorate or maintain status quo at best.

Taylor system : maximizes production performance

"Profit is a matter of opinion.

Cash is a reality."

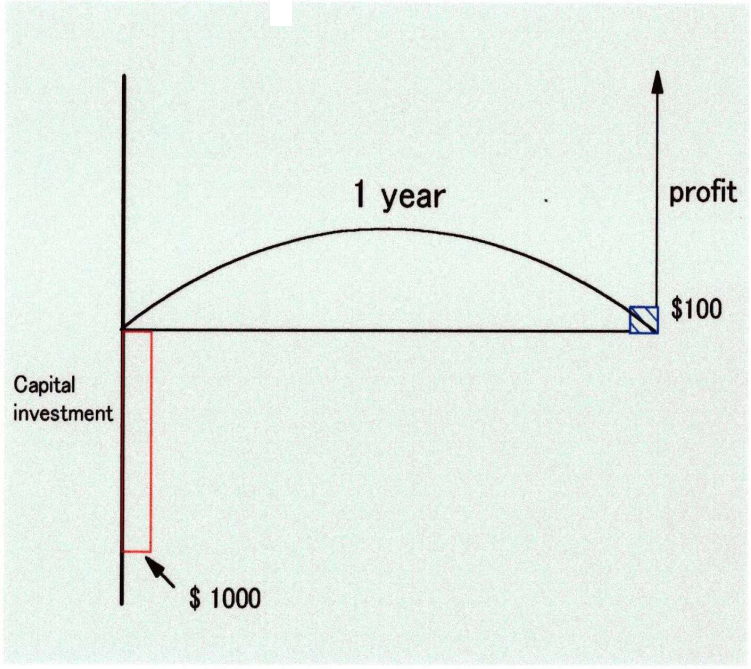
JIT system : maximizes capital efficiency

Two Performance Measures

(1) Ratio of gross profit to net sales
(2) Investment efficiency

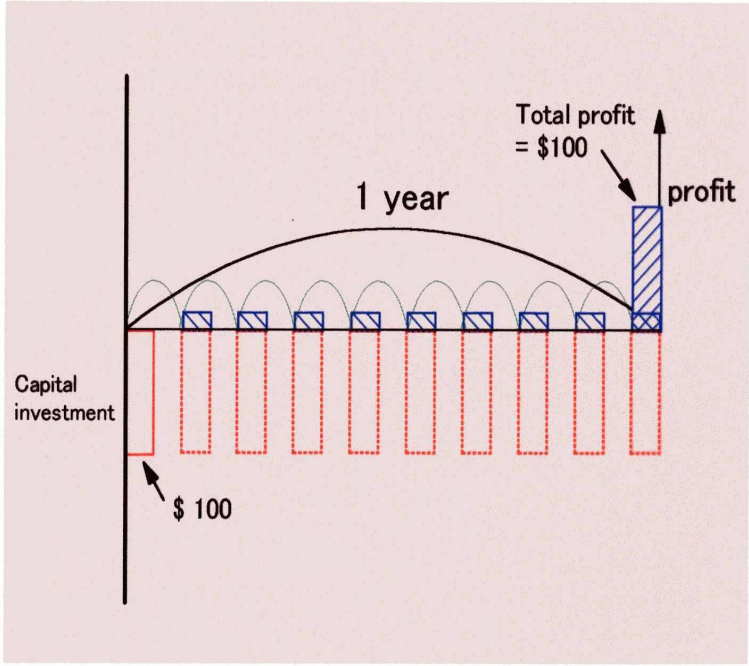
Two cases :

(1) Stock turns = 1



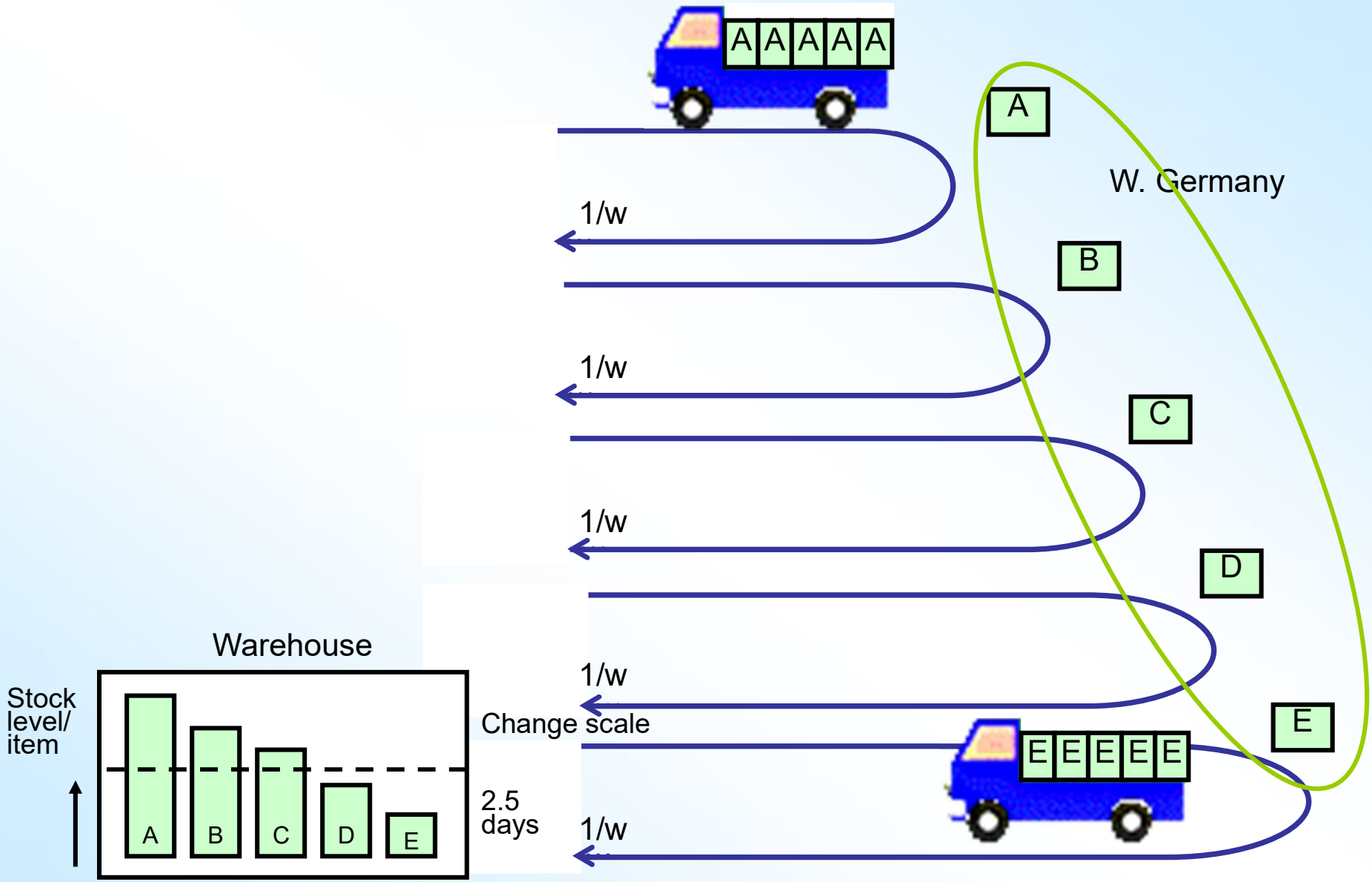
* (1) Ratio of gross profit to net sales = 10%
** (2) Money spent to earn $100 = $1000

(2) Stock turns = 10

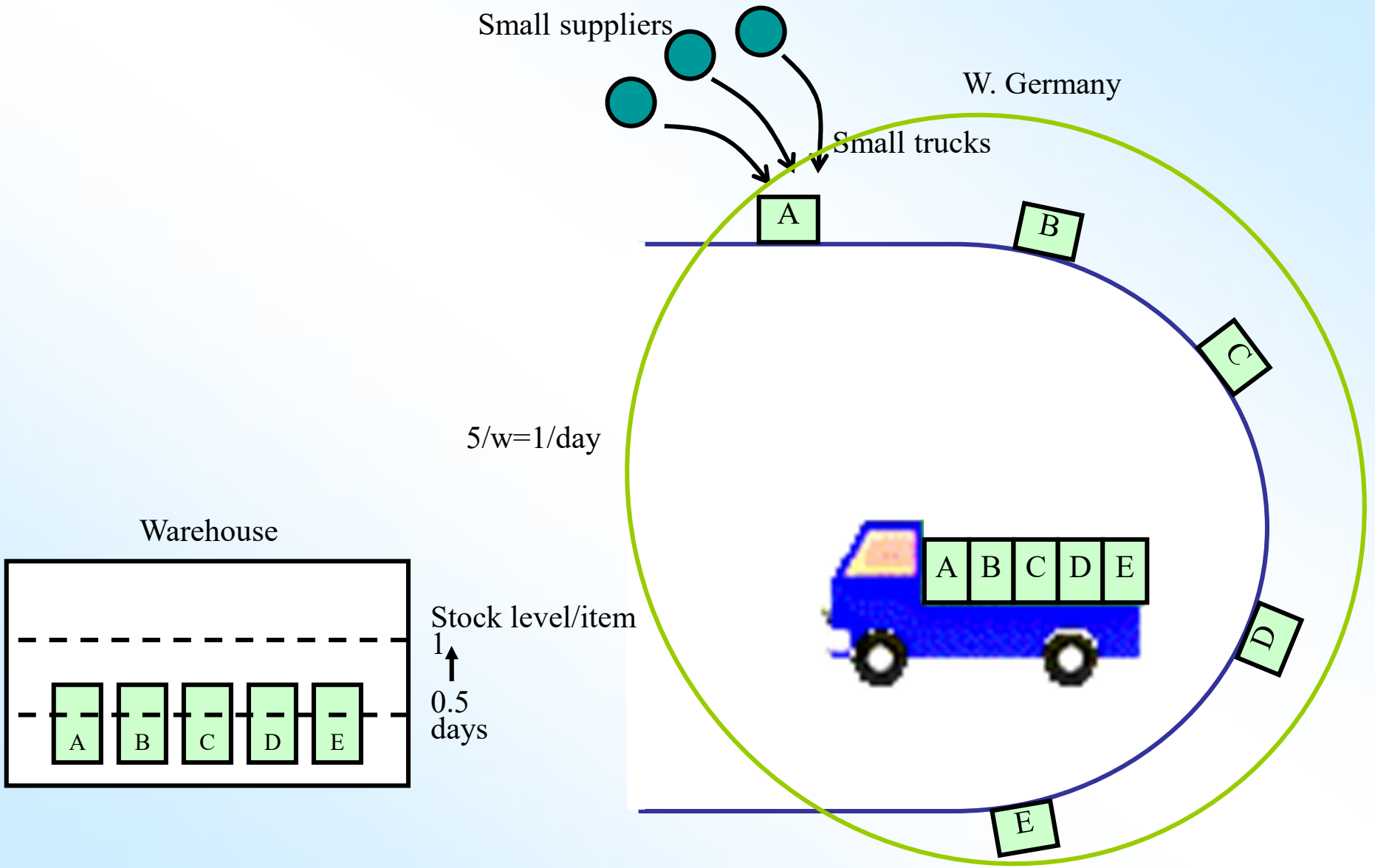


* (1) Ratio of gross profit to net sales = 10%
** (2) Money spent to earn $100 = $100

Delivery Per Item



Mixed Delivery



The tools developed in JIT philosophy

- Continuous flow production system
- Multi-process operation
- Setup time reduction
- Minimization of transfer batch sizes
- Visual management
- Fool proof devices
- Separated jobs of operation and transportation,

etc.

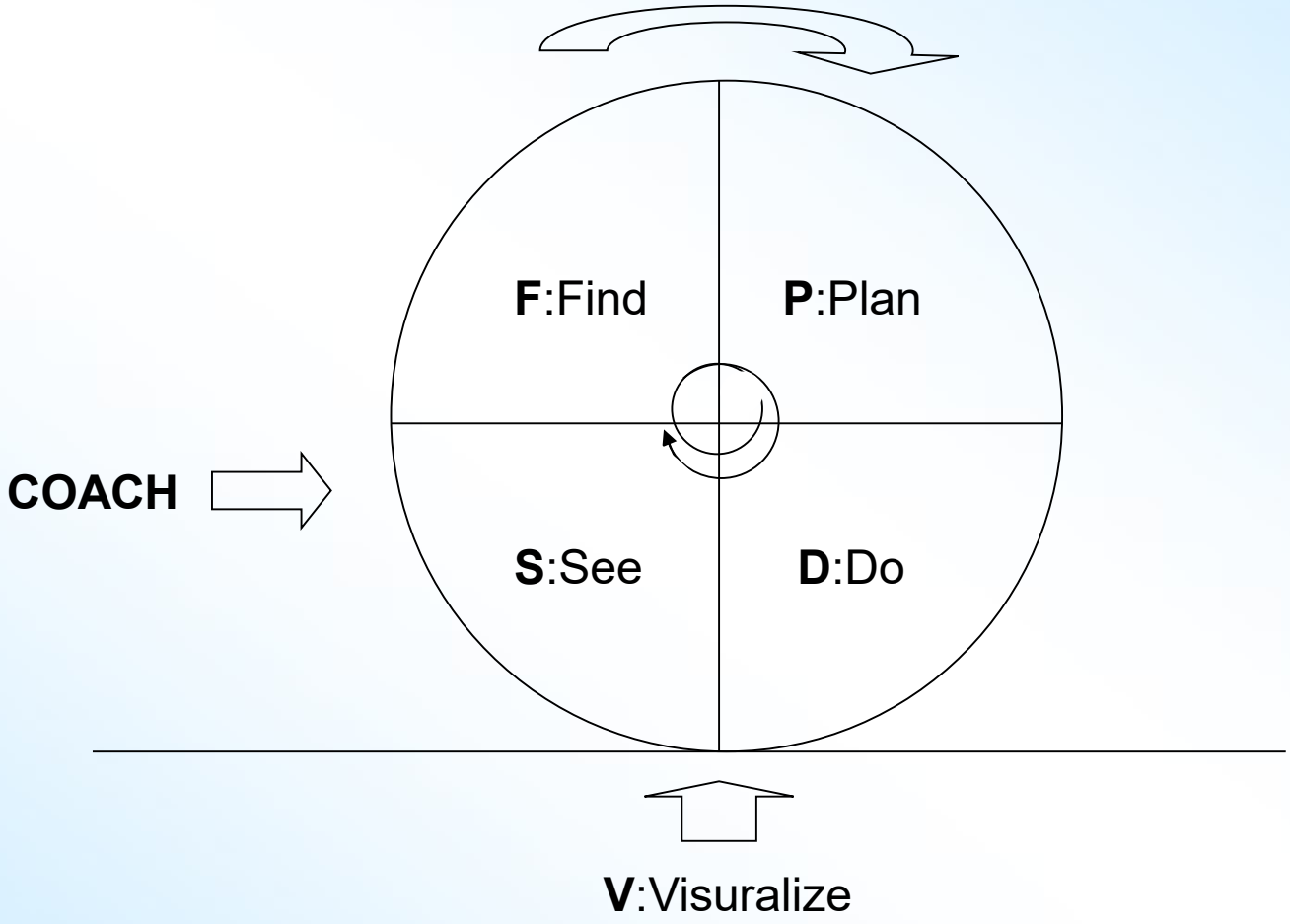
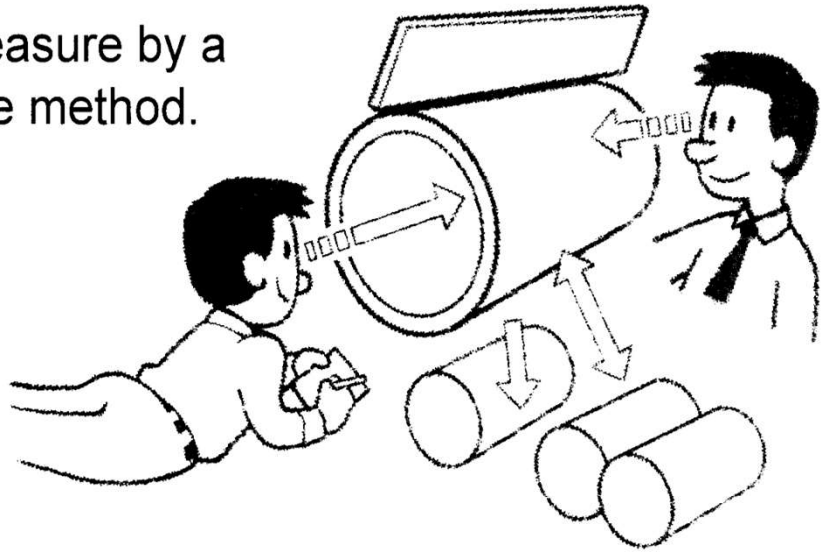


Fig. Practical P,D,C,A from the viewpoint of problem solving

④ Measure by a simple method.



① Check the place which can be seen.

③Put things in parallel. Check by comparison of the two.

② Check the place which is not easy to see.

Write down immediately what you have noticed.

Fig.

6. TIE

6.1 The definition of TIE
6.2 The tools developed in TIE philosophy
6.3 Elimination of the three main enemies of productivity
6.4 Pace monitor (Cont'd)
6.5 Operational Standard (OS)
* One page report

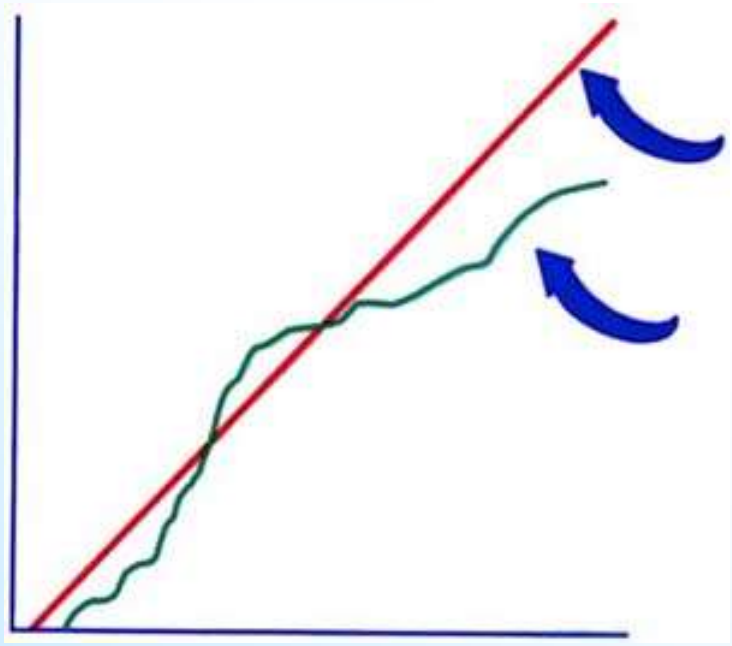
The definition of TIE

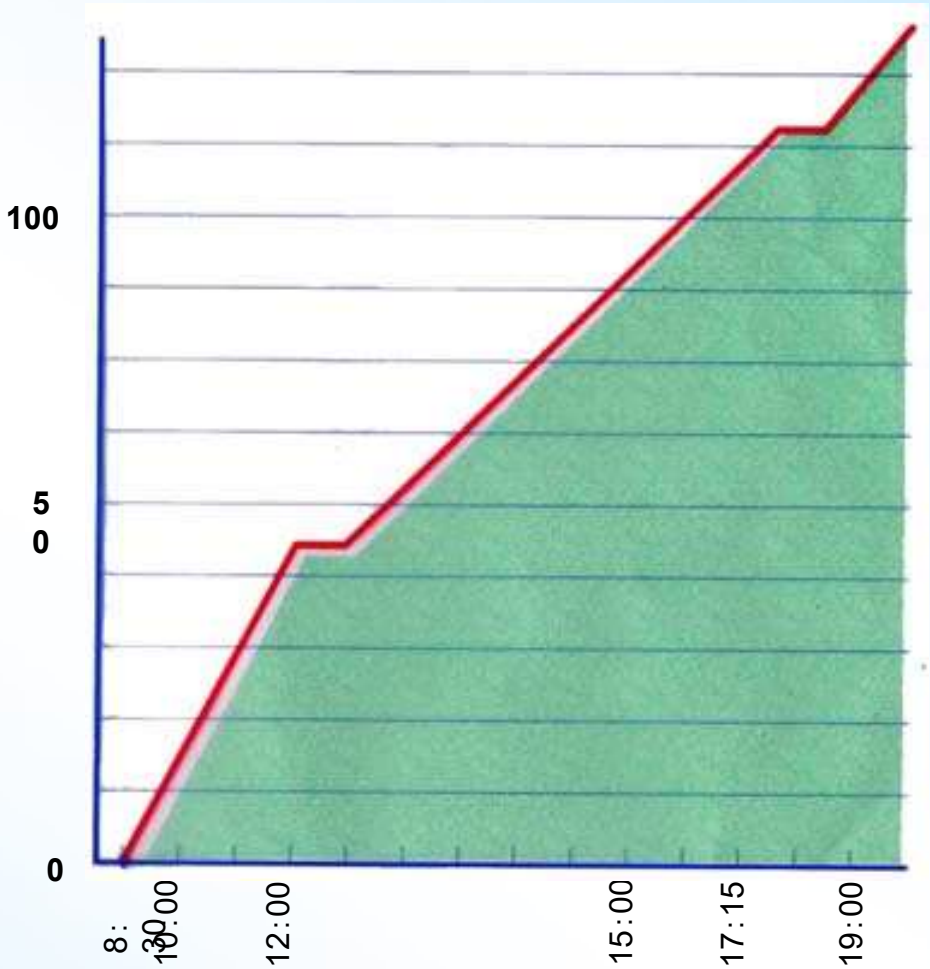
A system of methods whereby the performance of labor is maximized by reducing Muri (unnatural operation), Mura (irregular operation) and Muda (non-value added operation), and then separating labor from machinery through the use of sensor techniques.

Elimination of the three main enemies of productivity

	Cause	Solution	Comments
MURI	Difficult or unnatural operation	Ergonomic study	Without trial, this problem cannot be understood.
MURA	Irregular movement	Standard operation	Unless being observed for some time, this problem cannot be recognized.
MUDA	Waste	Reduction of N.V.A.A.	If observed properly, this problem can easily be noticed.

Pace monitor





Operational Standard (OS)

Level 1 : There is no OS. It is up to the operator how he does his operation.

Level 2 : There is OS, but the OS is not good enough to assure quality.

Level 3 : There is OS which assures quality, but the operator does not use it.

Level 4 : There is OS which assures quality and the operator follows it.

Level 5 : There is OS which assures quality and the operator follows it. There is a system to check whether the operator has followed it.

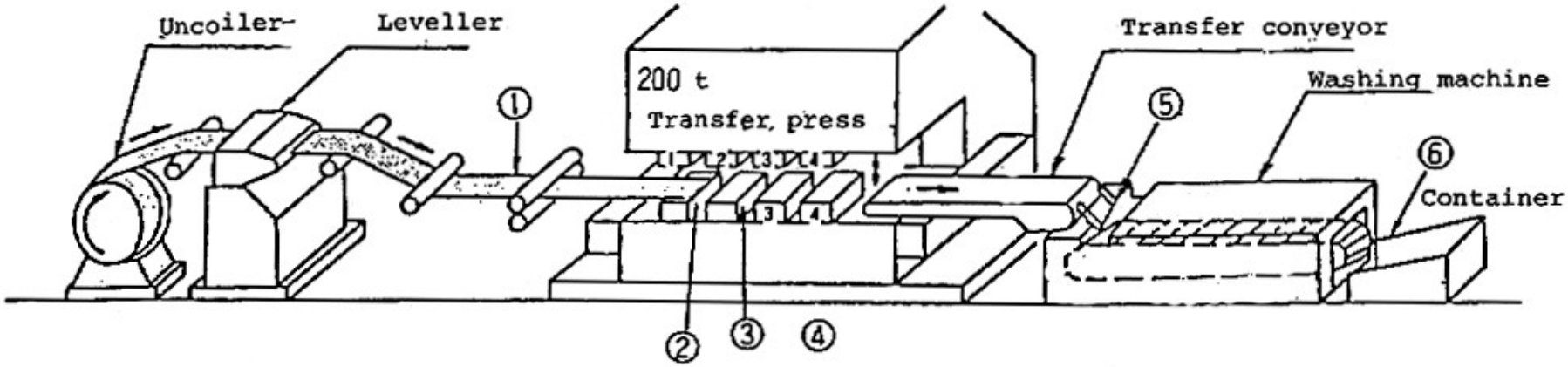
Furthermore, operation standard is considered to be a starting point of making continuous improvement and innovation.

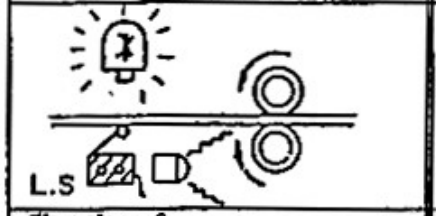
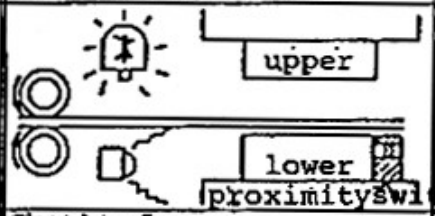
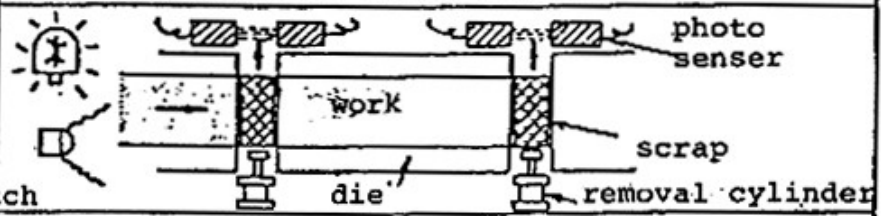
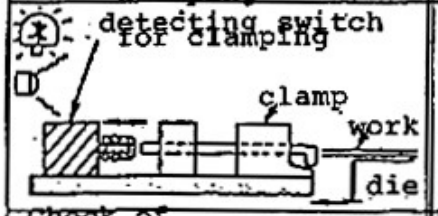
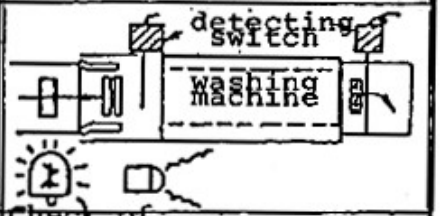
Note : There seems to be a little difference between levels 4 and 5. But actually, the results are very different.

Steps toward WCM

The steps toward WCM is to improve productivity by

1) minimizing material handling
2) eliminating MURI (difficult and unnatural operation), MURA (irregular operating) and MUDA (non-value added operation) by operational improvement
3) creating multi-skilled labor
4) introducing LCA systematically
5) achieving stable production by minimizing disturbances such as machine breakdowns
6) controlling abnormal situations by minimizing production of defectives and minor stoppages
   and
7) separating labor from equipment



① Conf. of material feeding	② Conf. of material setting on dies	③ Confirmation of scrap removal.
		
Check of contact → buzzer, lamp	Check of non-contact buzzer, lamp	Photo senser → buzzer, lamp
④ Conf. of work clamping	⑤⑥ Check of blocking	
		
Check of timing → lamp	Check of contact → buzzer, lamp	

By the introduction of fool proof devices,
reduction of one watching person
quality defective rate : 0.2 % → 0 %

The tools developed in TIE philosophy

- IE (Muri, Mura, Muda)
- Video camera method
- Standard operation
- Pace monitor
- Separation of labor from machinery
- Multi-skilled labor
- Skill development
- Separation of the labor from operation and the one from transportation, etc.

1. Theme	Prevention of overheat of bearings of the rotating mill	Loss :	Labor cost loss	Engineering dept.	

2. Reason for selection

The rotating mill is the main equipment and overheating mill bearings will create a serious breakdown.

3. Target value

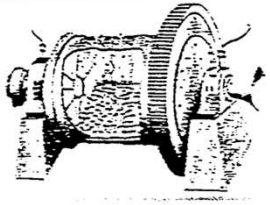
Breakdown : 0

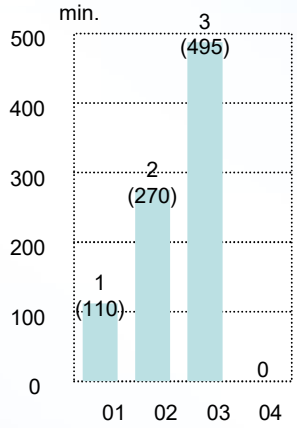
4. Results

Saving of repair cost : $19,700 / breakdown
Saving of labor cost : $1,010 / year

5. Analysis of the actual condition

Lost time due to breakdown by the overheat of the rotating mill bearings (6 mills)





Detection of problems

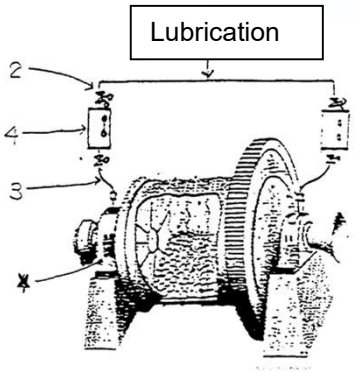
- Why does the bearing temperature increase? → Insufficient oil supply
  - Air gets in the pipe
    - 1. Leakage of oil in the hose during the operation stoppage
    - 2. Defective sealing at the joint sections
    - 3.Too long steel pipes and ore supply hoses
  - Difficult to carry out inspection
    - 4. The tank is not properly positioned

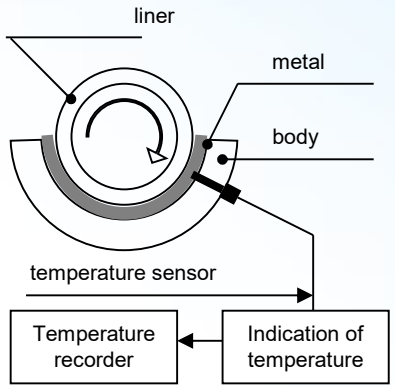
6. Contents of improvement

1. Train the operator how to lubricate manually at the start of operation
2. Refasten and / or replace joints
3. Replace steel pipes with vinyl pipes in order to make it easy to see their insides.
4. Check the oil gauge easily by changing the tank position

→ Transition to predictive maintenance

★ Installation of bearing temperature monitoring equipment





The rotating mill stops when the temperature goes over 65℃

7. Effect

Breakdowns caused by the overheat of the bearing : 0

8. The next step

Check the values of temperature sensors twice a year →±2℃ acceptable

7. Seven Steps to WCM and Major Pillars to Support WCM

7.1 Seven Steps to WCM —Priorities

7.2 What does cost deployment mean?

7.3 Major Pillars to Support WCM

7.3 The Major WCM Development Activities

7.4 Seven Steps of Cost Deployment

7.5 Seven Steps of Focused Improvement

7.6 Seven Steps of Autonomous Maintenance

7.7 Seven Steps of Professional Maintenance

7.8 Seven Steps of Quality Control

7.9 Seven Steps of Improving Customer Service

7.10 Seven Steps of E.E.M

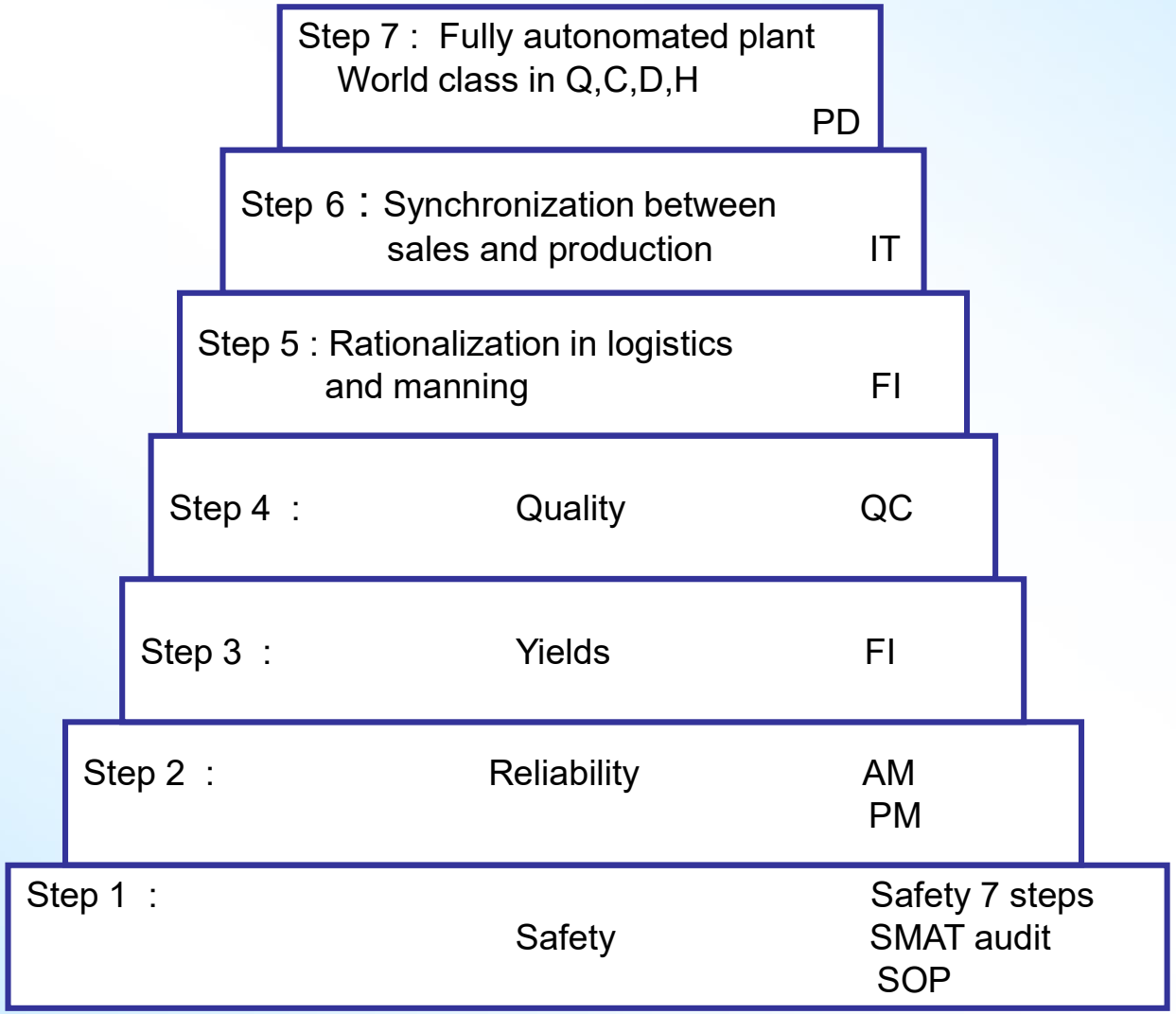
7.11 Seven Steps of People Development

7.12 Seven Steps of Safety

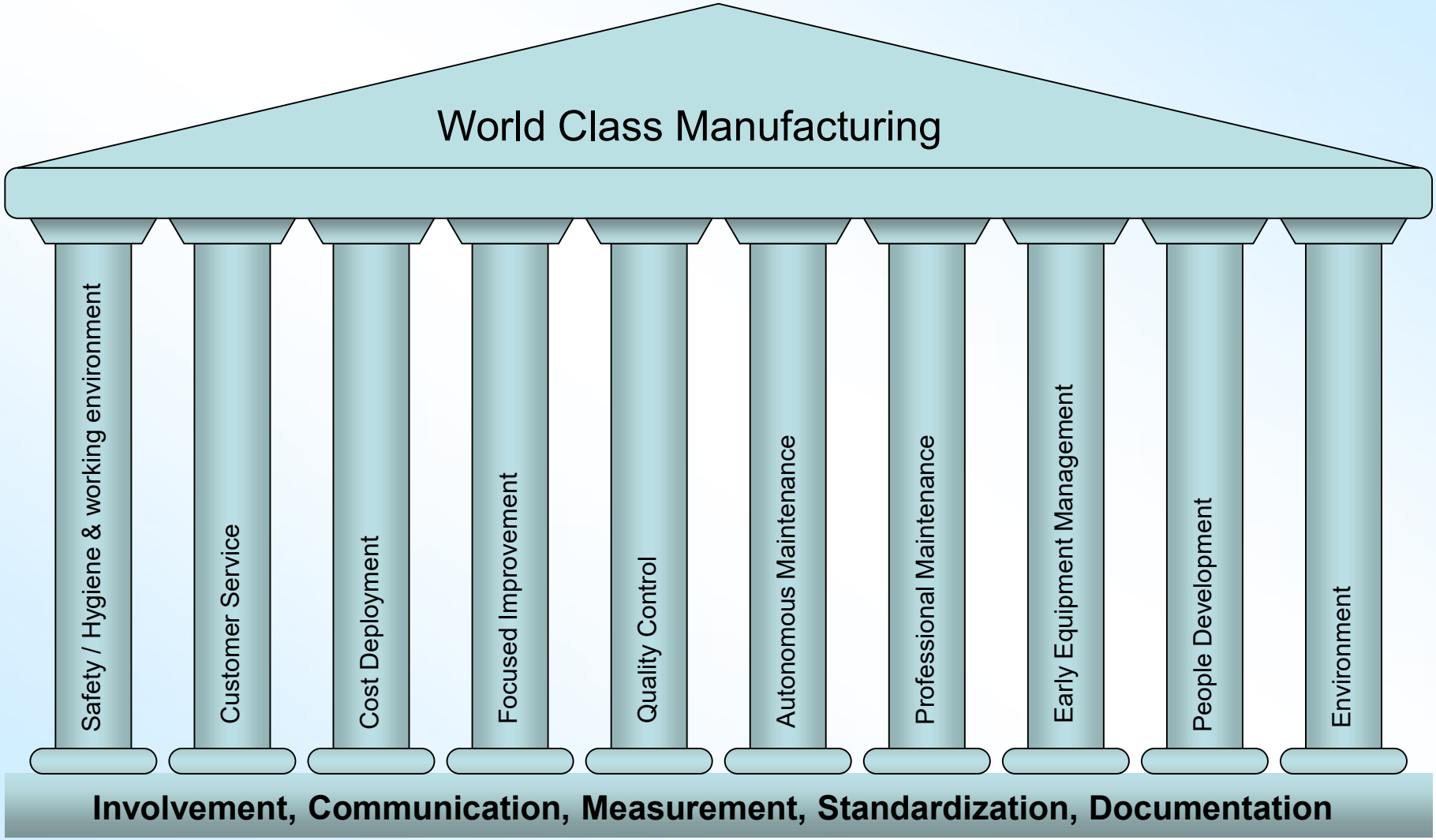
7.13 Seven Steps of Creating Good Environments

7.14 Educational subjects

7 Steps of WCM - Priorities



Major Pillars to Support WCM



The Major WCM Development Activities

Generally, the successful implementation of WCM requires as a base :

1. A safety, hygiene and working environment protection program
2. Improvement of Customer Satisfaction
3. Cost deployment to reduce cost systematically
4. Focused improvement for the elimination of the 16 big losses to improve equipment effectiveness and labor productivity
5. Elimination of defectives by a quality control program
6. An autonomous maintenance program
7. A scheduled maintenance program for the professional maintenance department
8. An early equipment management program
9. People Development
10. Creating good environments

Cost Deployment

One of the major drawbacks of the activities TPM, TQC, JIT, and TIE is the lack of direct relationship between an activity and its cost reduction benefit.

- No system is satisfactory without having the capability of evaluating cost.
- The existing accounting system is a very premature tool. It requires a substantial reform for meeting the requirement of making profit.
- The solution is to develop cost deployment.

What does cost deployment mean?

Cost deployment is the method that establishes a cost reduction program, scientifically and systematically with the cooperation between the financial department and the production department:

(1) by investigating the relationship among the cost factors, process generating costs and various kinds of waste and losses,

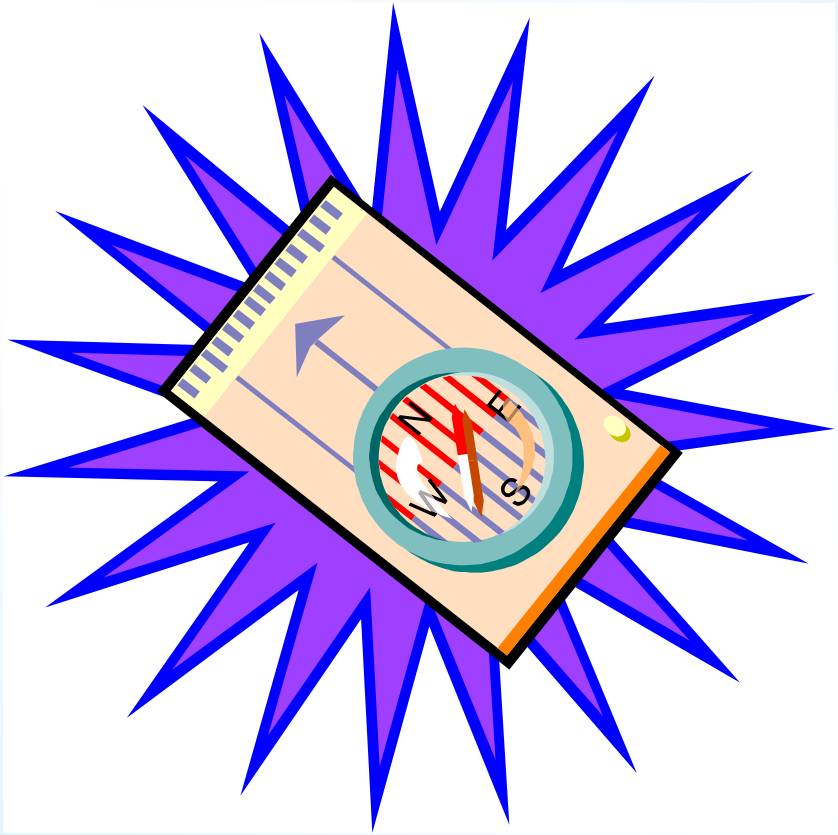
(2) by finding connection among waste, loss reduction and CR

(3) by clarifying if the knowhow on waste and loss reduction is available and by obtaining the knowhow if needed

(4) by ranking the items for waste and loss reduction according to priority based on cost and benefit analysis

(5)by establishing a cost reduction program for meaningful cost reduction.

- Our compass is Cost Deployment



Cost deployment identifies 18 big losses:

Equipment : 10 major losses

(Ⅰ) 7 major losses obstructing overall equipment effectiveness

1) Equipment downtime loss

(1) Equipment failure loss

Sudden and unexpected equipment failures or breakdowns, are an obvious cause of loss, since an equipment failure means, that the machine is not producing any output.

(2) Changeover loss

A changeover is determined by a planned variation in the production plan or replacing tools / dies due to wear and tear or being broken.

(3) Set-up & adjustment loss

Most machine changeovers require some period of shutdown so that internal components can be exchanged or adjusted. The time between the end of the last good product produced and the first good product produced of the following production run is downtime. This downtime loss often includes substantial time spent making adjustments until the machine gives acceptable quality on the required product.

(4) Cutting blade change loss

(5) Start-up loss / Shut down loss

The start up loss occurs for the period of time preparing the line for starting up and running in the equipment until conditions have been stabilized. Yield losses occur when production is not immediately stable at equipment start-up, so the first products do not meet specifications. This is a latent loss, often accepted as inevitable, and it can be surprisingly large.

Other downtime

Management losses and such waiting losses as (awaiting instruction loss, awaiting material loss, awaiting personnel distribution loss) and quality confirmation waiting loss (Adjustment of measurement)

2) Equipment performance loss

(6) Minor stoppage and idling losses
(abnormal operation of sensors, blockage of work on chutes, etc.)

When a machine is running and stop / starting frequently, it will lose speed and obstruct a smooth flow. The idling and stoppages in this case are not caused by technical failures, but small problems such as product(s) that block sensors or get caught in chutes. Even though the operator can easily correct such problems when they occur, the frequent stoppages can significantly reduce the effectiveness of the equipment.

(7) Speed loss
(discrepancies between designed and actual speed of equipment)

Reduced speed operation refers to the difference between the actual operating speed and the equipment's designed speed (also referred to as theoretical). There is often a gap between what people believe is the "maximum" speed and the actual designed (theoretical) maximum speed. The aim is to eliminate the gap between the actual speed and the designed speed. Significant losses from reduced speed operation are often neglected or underestimated.

3) Defect loss

(8) Defects and rework loss

Loss occurs when products do not meet quality specifications, even if they can be reworked to correct the problem. The goal should be zero defects – to make the product right first time, every time.

(Ⅱ) Losses in equipment loading time

(9) Shutdown loss

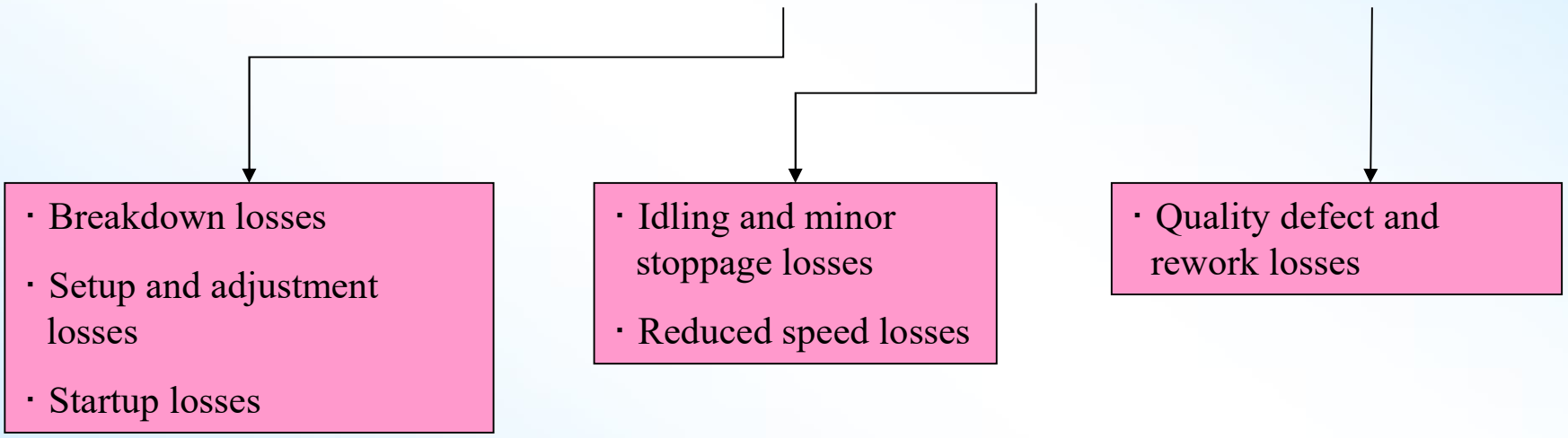
Other scheduled downtime losses due to no loading, no material and labor shortage

(10) Unused time loss

This is the period of time during the week where the equipment is not staffed due no weekend working, bank holidays or factory shutdown having an impact on loading time.

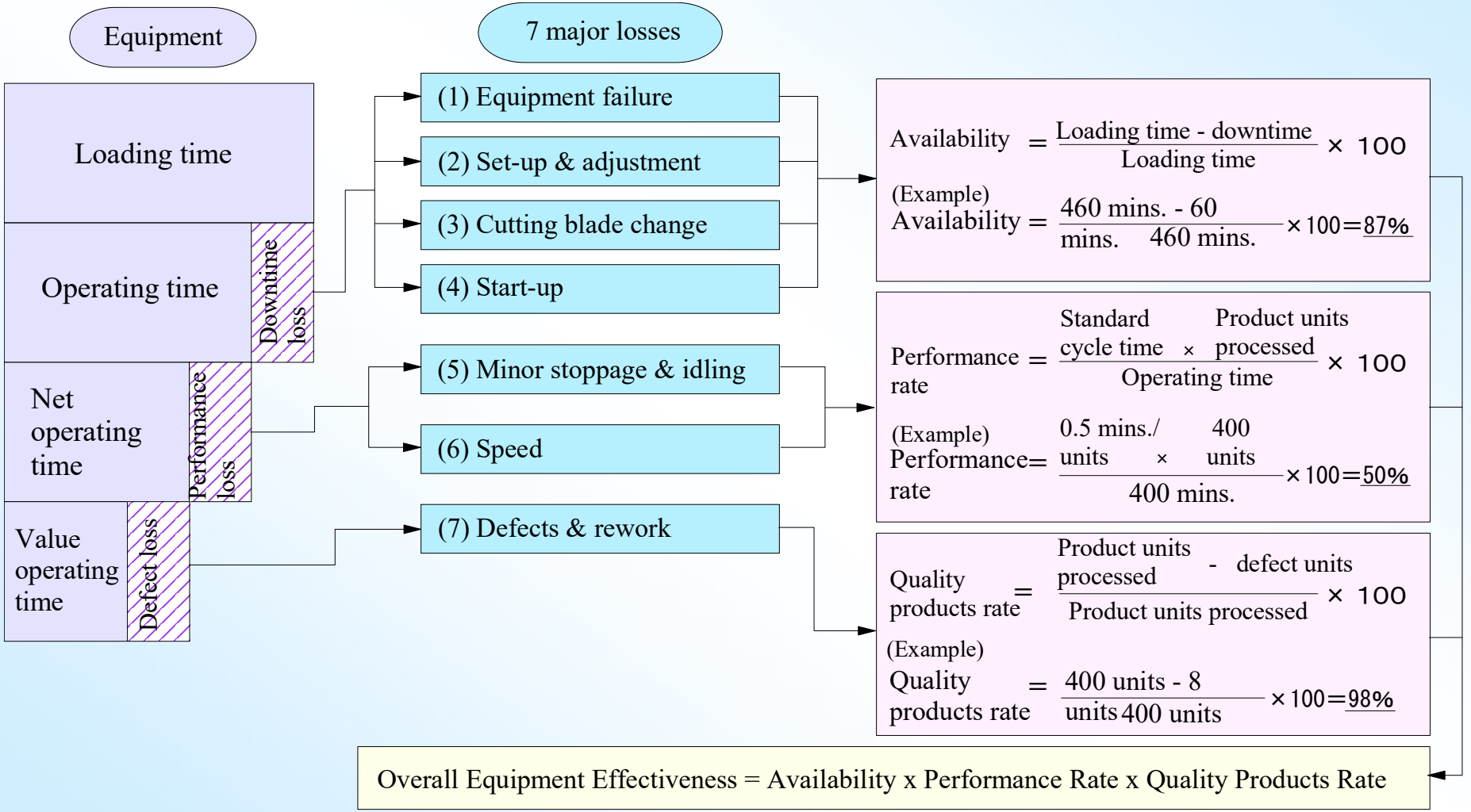
Definition of Overall Equipment Effectiveness

Overall equipment effectiveness = Availability x Performance rate x Quality rate



TPM improvement goals

Relationship between 7 Major Losses on Equipment and Overall Equipment Effectiveness



(Example) 0.87 x 0.50 x 0.98 x 100 = 42.6(%)

Labour : 5 major losses

(Ⅰ) Production manhour loss

(11) Management loss
(such loss as awaiting instruction or material loss)

(12) Operating motions loss
(production manhour loss such as equipment breakdown loss and equipment performance loss, method/procedure loss, skill & morale loss)

(Ⅱ) Line organization manhour loss

(13) Line organization loss
(line organization loss, loss due to failure to automate)

(14) Logistics loss
(transportation loss)

(Ⅲ) Defect quality loss

(15) Measurement and adjustment loss

Material and energy : 3 major losses

(16) Material yield loss

defects quality loss, cutting loss, start-up loss, losses in weight, losses in overages

(17) Energy loss

start-up loss, overload loss, temperature loss

(18) Maintenance spare parts loss

Cost of physical consumption of spare parts on refurbishment of items on the line. (This loss does not have an impact on OEE)

Other loss such as Jig & die loss

Cost deployment identifies 27 big losses in case of process industries :

Equipment : 12 major losses

(I) Losses in equipment loading time

(1) Shutdown loss

Shutdown loss is time lost when production stops for planned annual shutdown maintenance or periodic servicing.

(2) Production adjustment loss

Production adjustment loss is time lost when changes in supply and demand require adjustment in production plans.

(3) Unused time loss

This is the period of time during the week where the equipment is not staffed due to no weekend working, bank holidays or factory shutdown having an impact on loading time.

(II) 9 major losses obstructing overall plant effectiveness

1) Equipment downtime loss

(4) Equipment failure loss

Equipment failure loss is time lost when a plant stops because equipment suddenly loses its specified functions.

(5) Process failure loss

Process failure loss is time lost when a plant shuts down as a result of factors external to the equipment, such as operating errors or changes in the physical or chemical properties of the substances being processed.

2) Equipment performance loss

(6) Minor stoppage and idling losses

(7) Start-up loss / Shut down loss

(8) Changeover loss

(9) Setup loss and adjustment loss

(10) Abnormal production loss/speed loss

Abnormal production losses are rate losses that occur when a plant performs inadequately as a result of malfunctions and other abnormal conditions that interfere with performance.

3) Defect loss

(11) Quality defect loss

Quality defect losses include time lost in producing rejectable product, physical loss in scrap and financial losses due to product downgrading.

(12) Reprocessing loss

Reprocessing losses are recycling losses that occur when rejected material must be returned to a previous process to make it acceptable.

Material and energy : 5 losses

(13) Raw material losses

(14) Unit consumption losses

$$\bullet \text{ Unit consumption of subsidiary materials} = \frac{\text{Subsidiary materials used}}{\text{Amount of product}} \ (\text{kg/t})$$

$$\bullet \text{ Unit consumption of fuel} = \frac{\text{Fuel used}}{\text{Amount of product}} \ (\text{k}\ell/\text{t})$$

$$\bullet \text{ Unit consumption of electrical power} = \frac{\text{Electrical power used}}{\text{Amount of product}} \ (\text{kWh/t})$$

$$\bullet \text{ Unit consumption of packaging materials} = \frac{\text{Packaging materials used}}{\text{Amount of product}} \ (\text{rolls/t})$$

(15) Maintenance materials loss

(16) Leakage and spillage losses

(17) Energy loss

Labor

(I) Production manhour loss

(18) Work losses

Work losses include wasteful human labor necessitated by a plant's poor operating condition. A plant that develops abnormalities or faults generates extra work, such as inspecting and reporting on the faulty equipment and making appropriate adjustments. Taking emergency action and following up on process failures characteristic of process plants (leaks, spills, blocks and so on) require many work-hours.

(19) Cleaning loss

(20) Inspection loss

(21) Lubrication loss

(22) Testing and analysis losses

(II) Line organization manhour loss

(23) Management losses

Management losses are losses that arise from poor management systems or poor operation of those systems.

(24) Failures loss of not introducing new control systems of personnel reduction

(25) Failure loss of not centralizing and simplifying processes

(26) Logistics loss

(III) Defect quality loss

(27) Defect quality loss

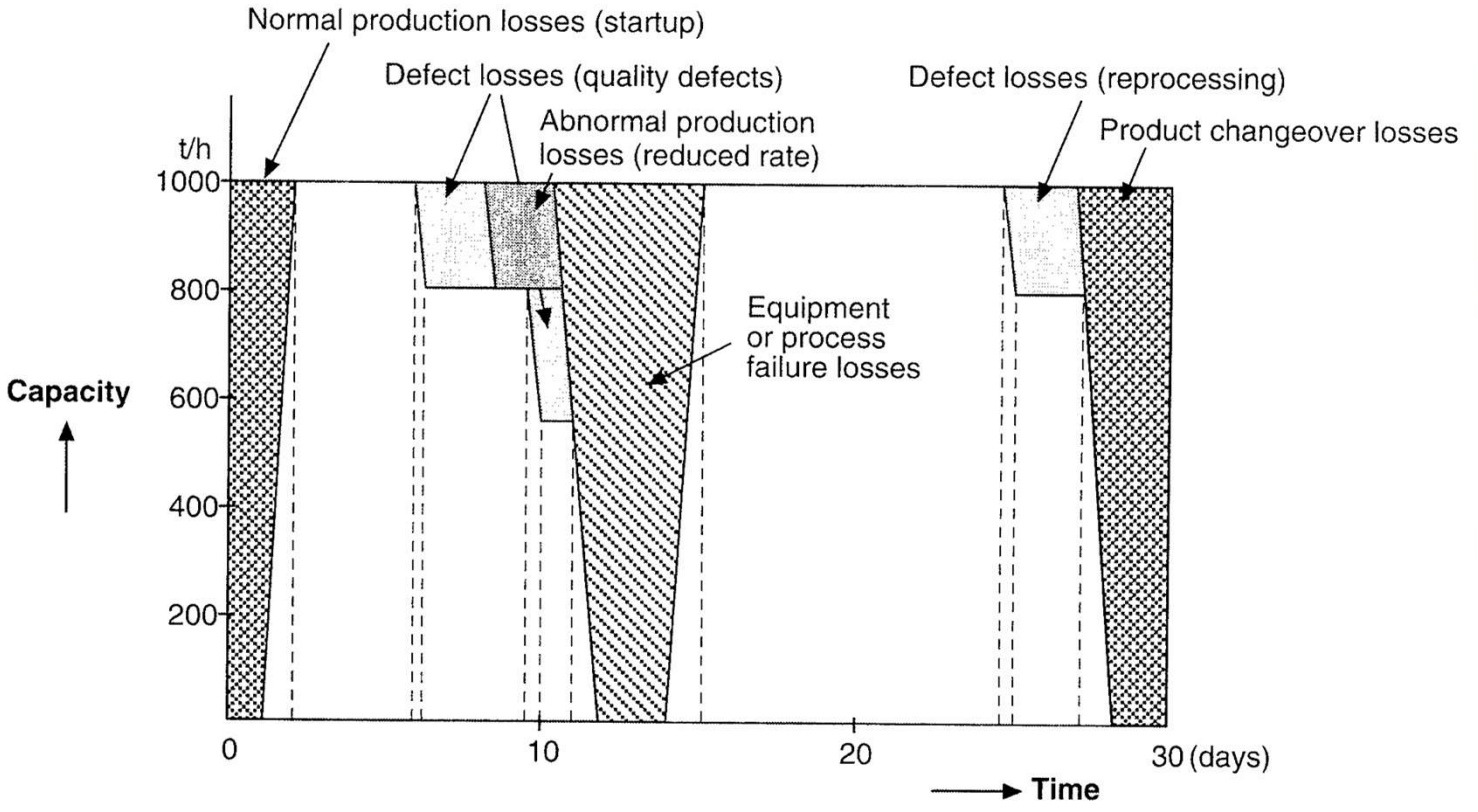


Figure : Production and the Eight Major Losses

The structure of losses

Calendar time

Calendar time is the number of hours on the calendar :

365 x 24 = 8,760 hours in a year

30 x 24 = 720 hours in a 30-day month.

Working time

Working time is the actual number of hours that a plant is expected to operate in a year or month. To calculate working time, subtract from the calendar time the time lost as a result of closing the plant for production adjustment or for periodic servicing such as shutdown maintenance.

Operating time

Operating time is the time during which a plant actually operates. To calculate operating time, subtract from the working time the time a plant loses when it shuts down as a result of equipment and process failures.

Net operating time

Net operating time is the time during which a plant is producing at the standard production rate. To calculate net operating time, subtract performance time losses from the operating time.

Availability

Availability is the operating time expressed as a percentage of the calendar time.

$$\text{Availability} = \frac{\text{Calendar time} - (\text{shutdown loss} + \text{major stoppage loss})}{\text{Calendar time}} \times 100\ (\%)$$

Shutdown losses = shutdown maintenance loss + production adjustment loss

Major stoppage loss = equipment failure loss + process failure loss

Performance rate

A plant's ***performance rate*** expresses the actual production rate as a percentage of the standard production rate.

The standard production rate is equivalent to a plant's design capacity and is the intrinsic capacity of a particular plant.

$$\text{Performance rate} = \frac{\text{Average actual production rate (t/h)}}{\text{Standard production rate (t/h)}} \times 100(\%)$$

$$= \frac{(D)}{(C)} \times 100(\%)$$

$$\text{average actual production rate} = \frac{\text{Actual production rate (t/h)}}{\text{Operating time}}$$

Quality rate

The ***quality rate*** expresses the amount of acceptable product (total production less downgraded product, scrap, and reprocessed product as a percentage of total production.

$$\text{Quality rate} = \frac{\text{Production quantity (t)} - (\text{quality defect loss} + \text{reprocessing loss})\ (t)}{\text{Production quantity (t)}}$$

$$\frac{(E)}{(D)} \times 100\ (\%)$$

Overall plant effectiveness

Overall plant effectiveness is the product of the availability, performance rate, and quality rate.

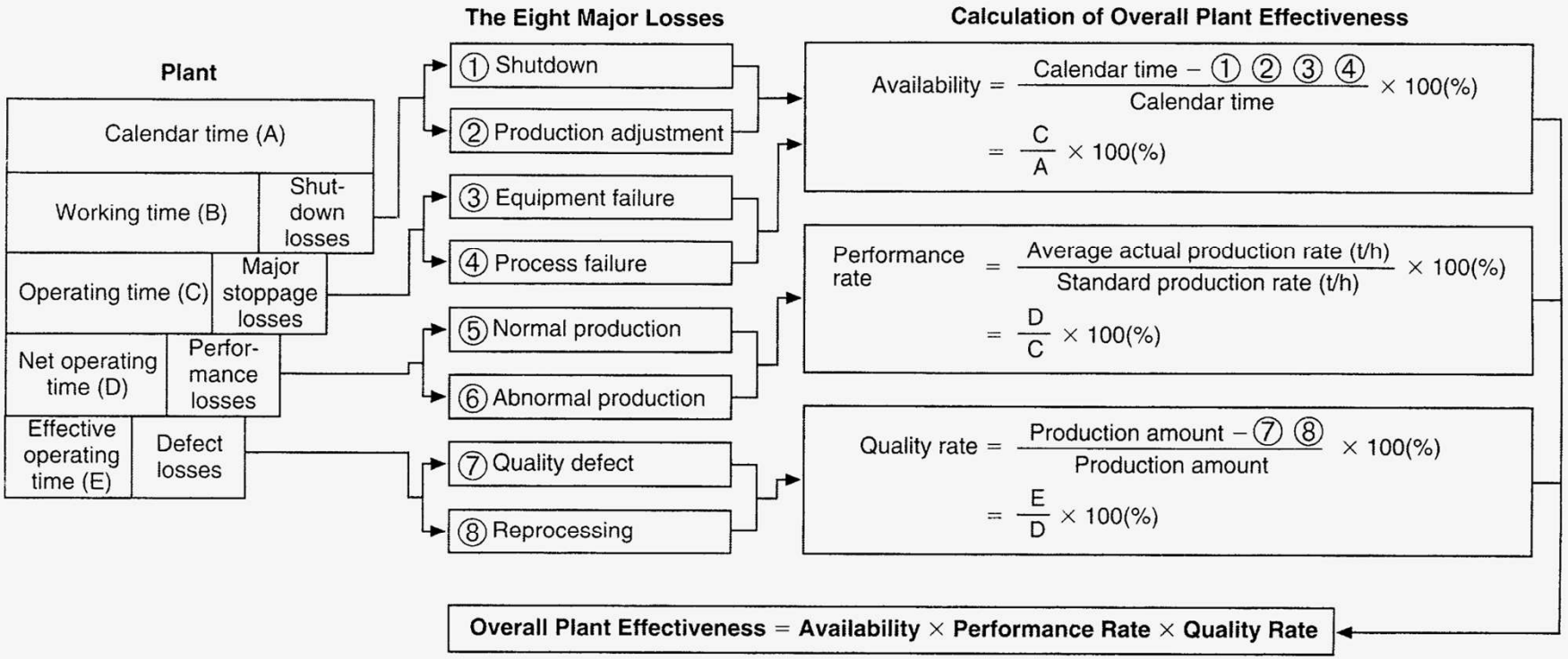


Figure Overall Plant Effectiveness and the Structure of Losses

Example :

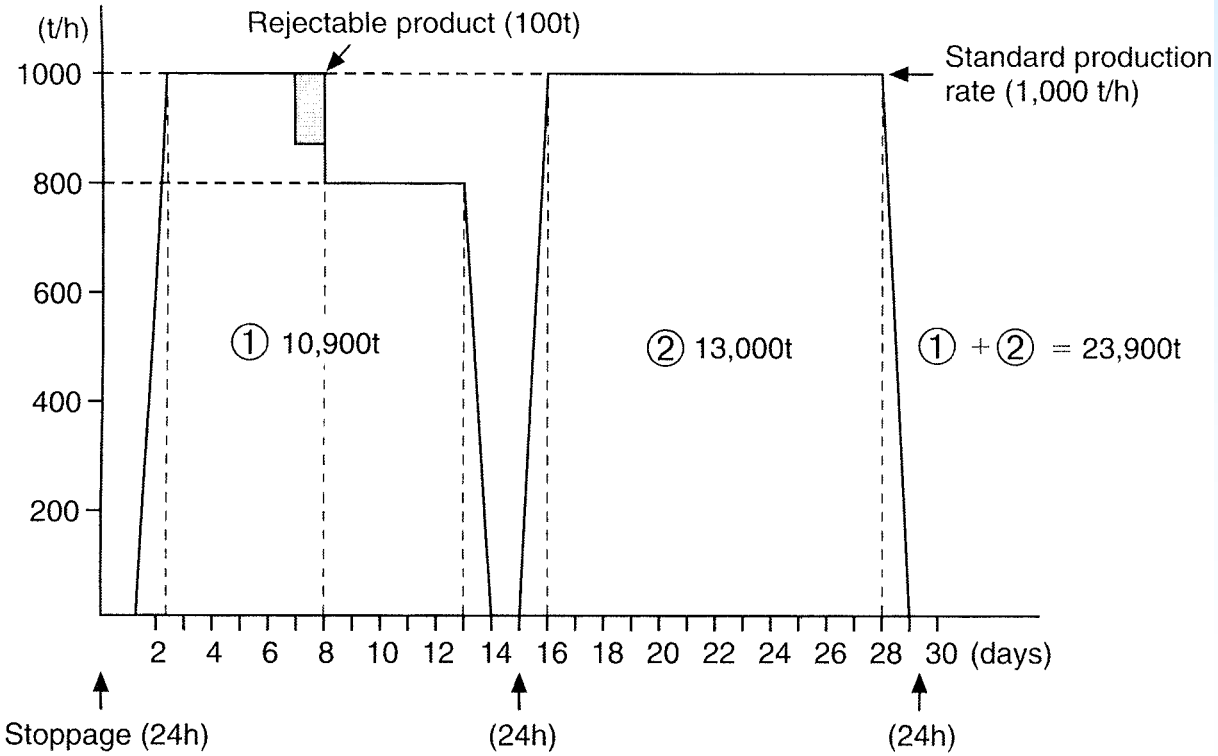


Figure Example of Calculation of Overall Plant Effectiveness

Calendar time: 24 hrs × 30 days

Operating time: 24 hrs × 27 days

$$\therefore \text{ A. Availability} = \frac{24 \times 27}{24 \times 30} \times 100 = 90\%$$

Actual production volume:

1. (500 t/day × 1 day) + (1,000 t/day × 6 days)
   + (800 t/day × 5 days) + 400 t/day × 1 day = 10,900 t
2. (500 t/day × 1 day + 1,000 t/day × 12 days)
   + (500 t/day × 1 day) = 13,000 t

Total: 10,900 + 13,000 = 23,900 t

$$\therefore \text{ Actual production rate: } \frac{23{,}900}{27} = 885 \text{ t/day}$$

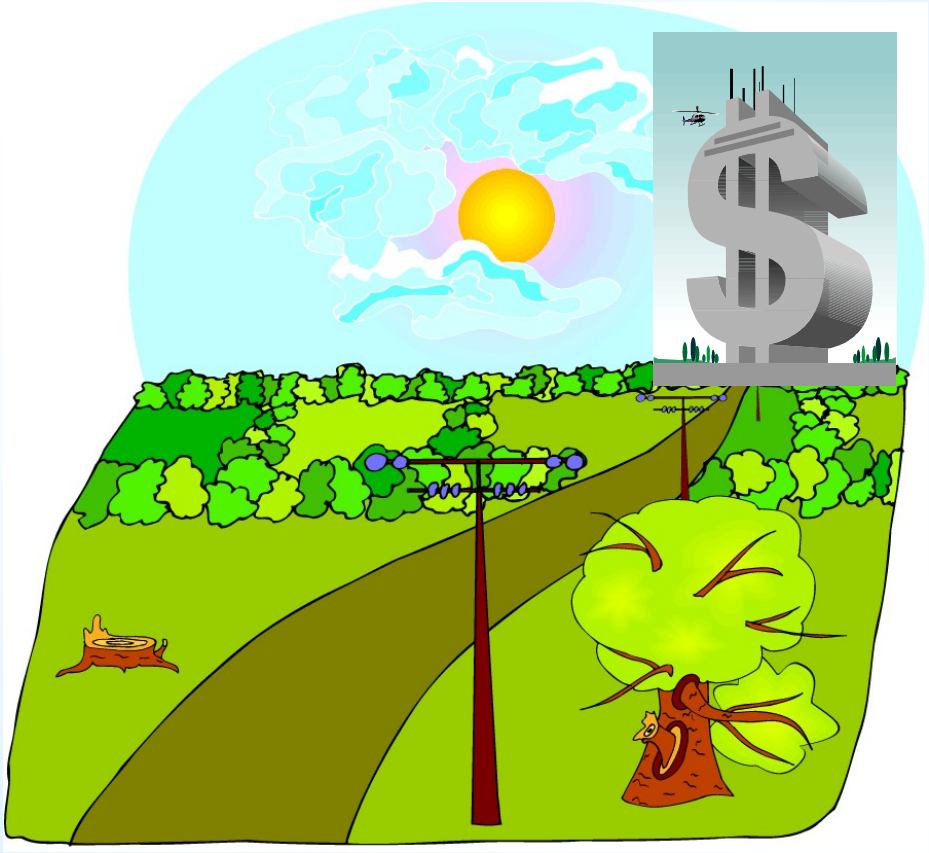
$$\text{B. Performance rate} = \frac{885}{1{,}000} \times 88.5\%$$

If 100 t of rejectable product are produced,

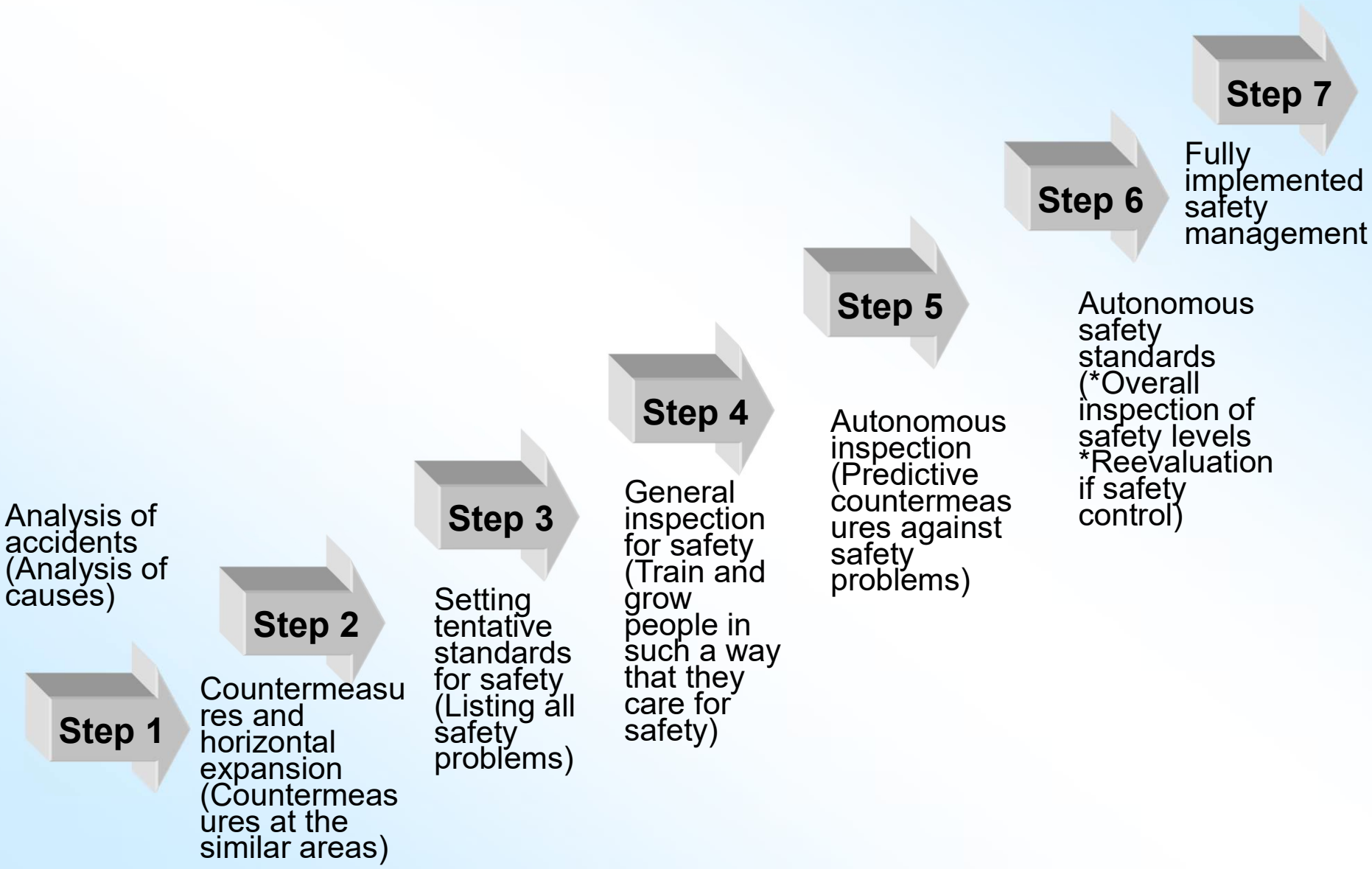
$$\text{C. Quality rate} = \frac{23{,}800 \text{ t}}{23{,}900 \text{ t}} \times 100 = 99.6\%$$

$$\text{D. Overall plant effectiveness} = (\text{A}) \times (\text{B}) \times (\text{C}) \times 100$$
$$= (0.9 \times 0.885 \times 0.966) \times 100$$
$$= 79.3\%$$

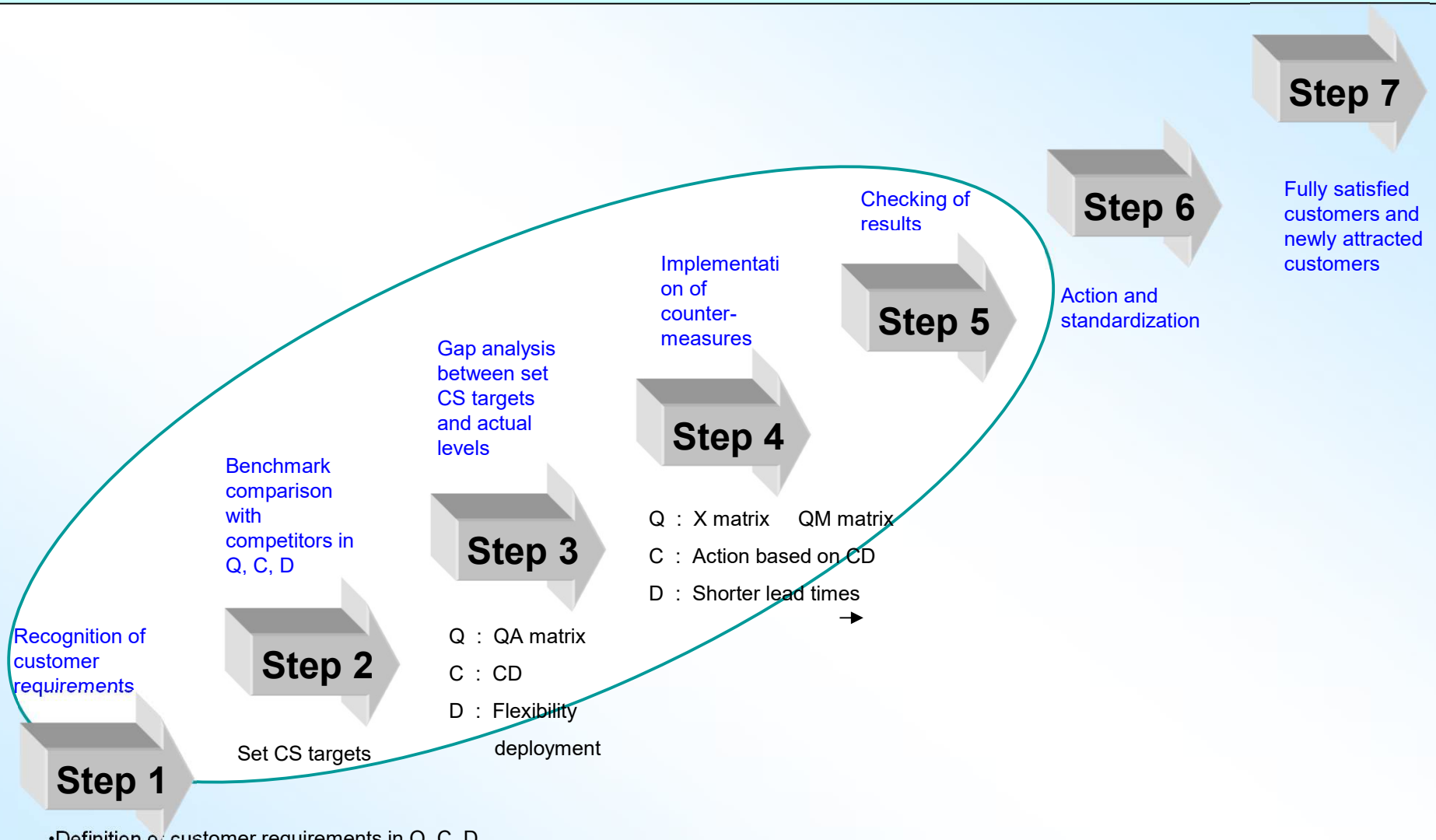
- But the value lies in our journey

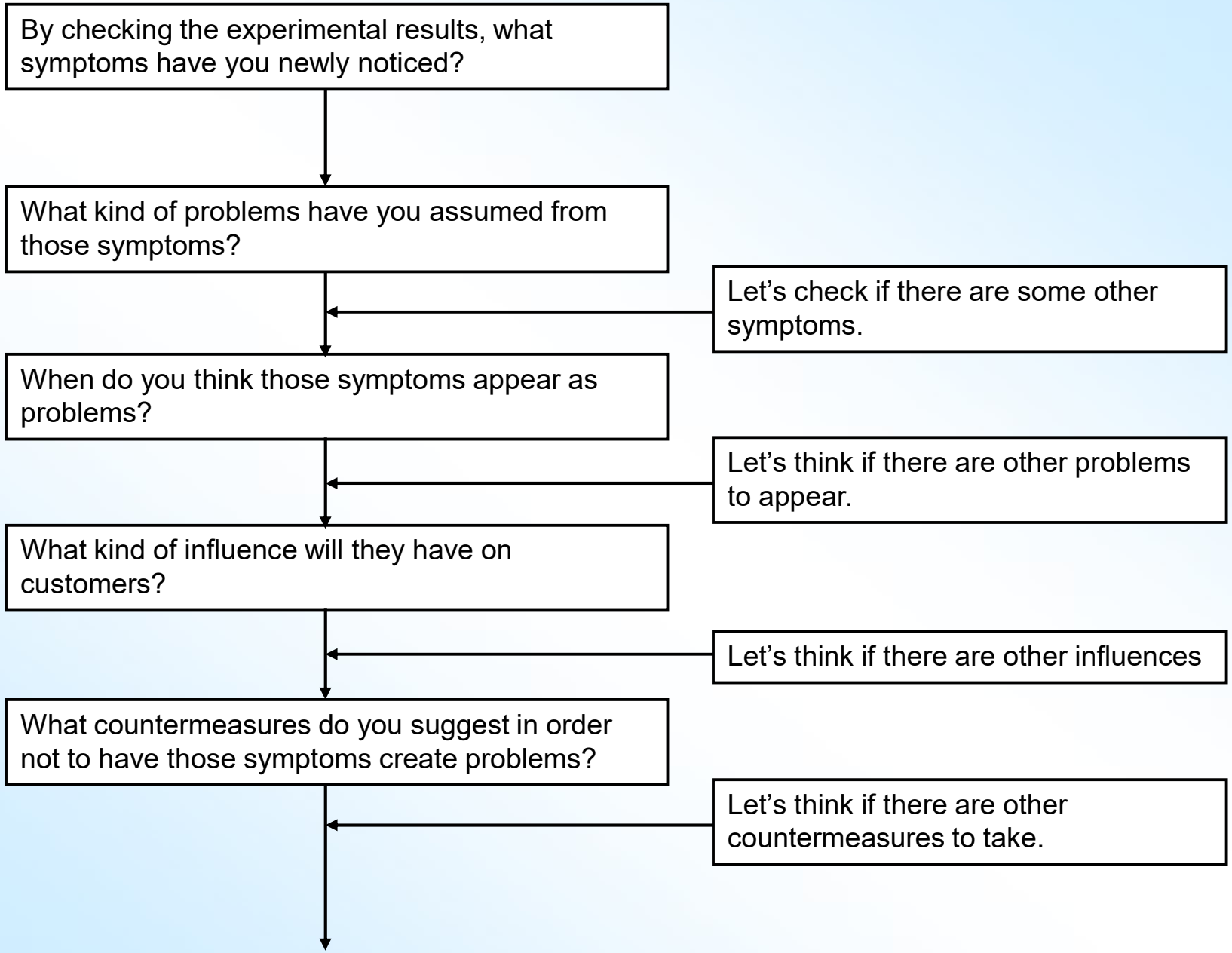


Seven Steps of Safety



Seven Steps of Improving Customer Service



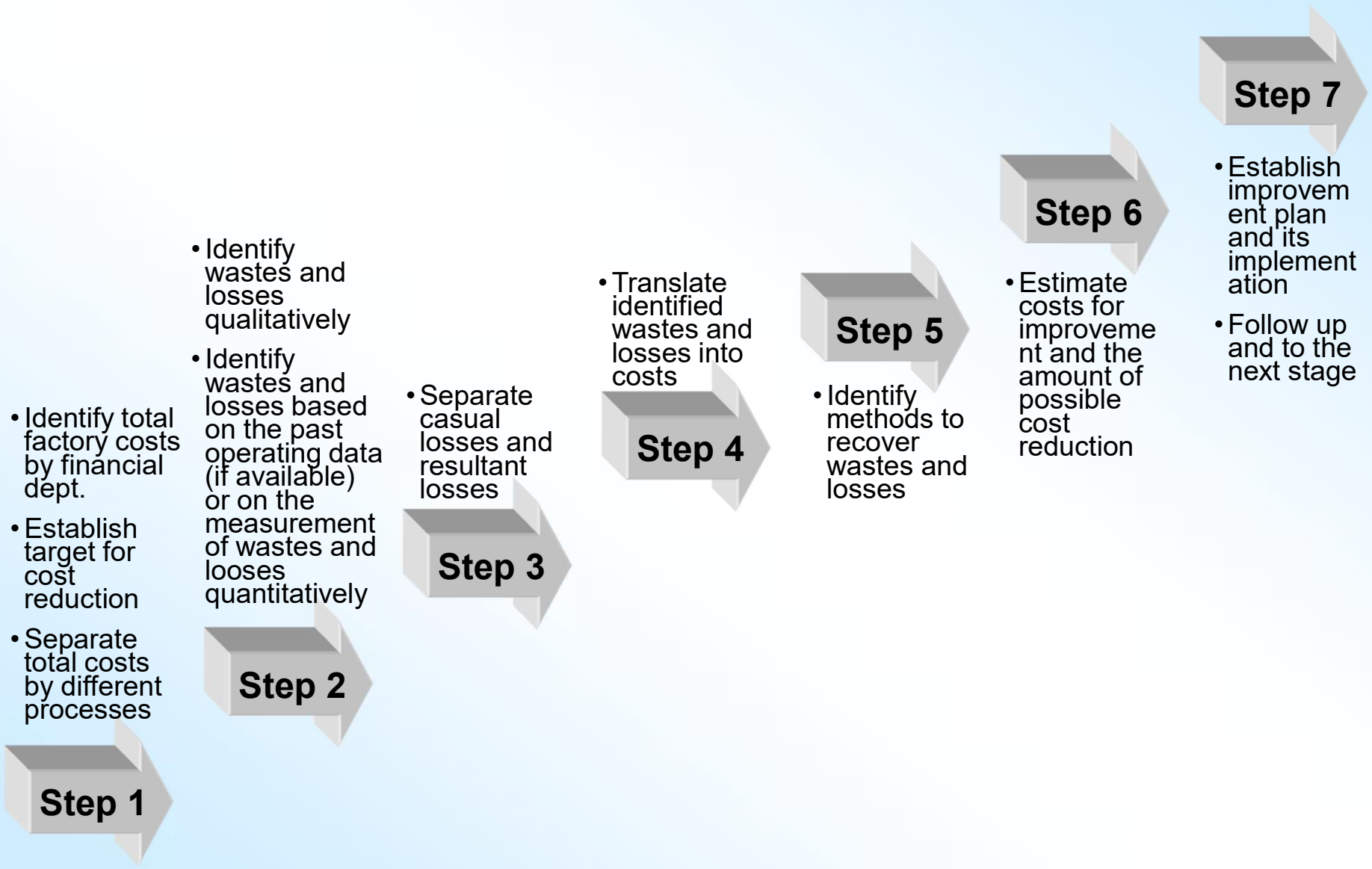

By checking the experimental results, what symptoms have you newly noticed?
What kind of problems have you assumed from those symptoms?
Let's check if there are some other symptoms.
When do you think those symptoms appear as problems?
Let's think if there are other problems to appear.
What kind of influence will they have on customers?
Let's think if there are other influences
What countermeasures do you suggest in order not to have those symptoms create problems?
Let's think if there are other countermeasures to take.

Cost Deployment

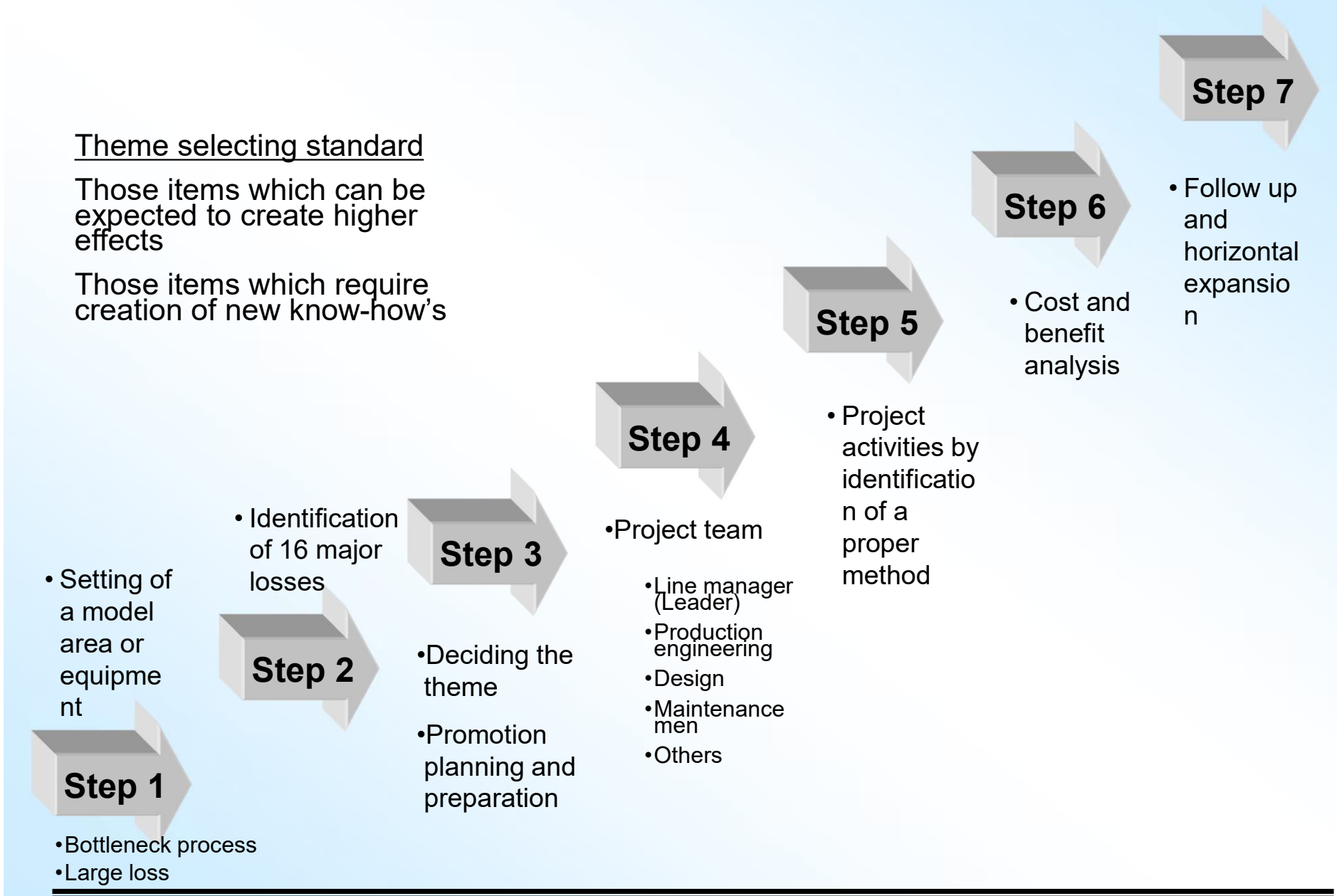
Based on the route to WCM, we must be able to identify to which level of the 7 steps we must achieve in order to realize the set cost reduction target.

We must have better eyes step by step.

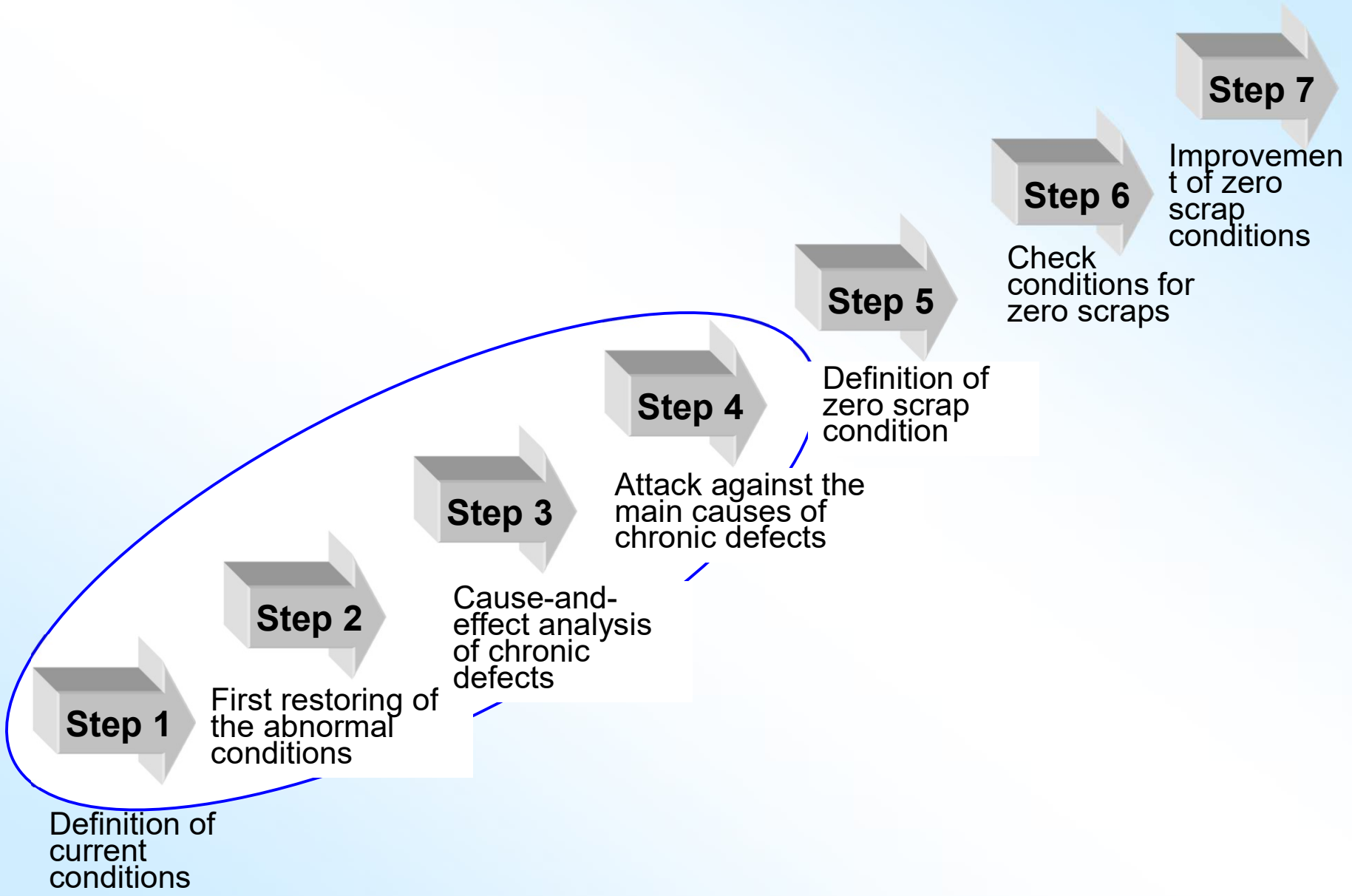
Seven Steps of Cost Deployment



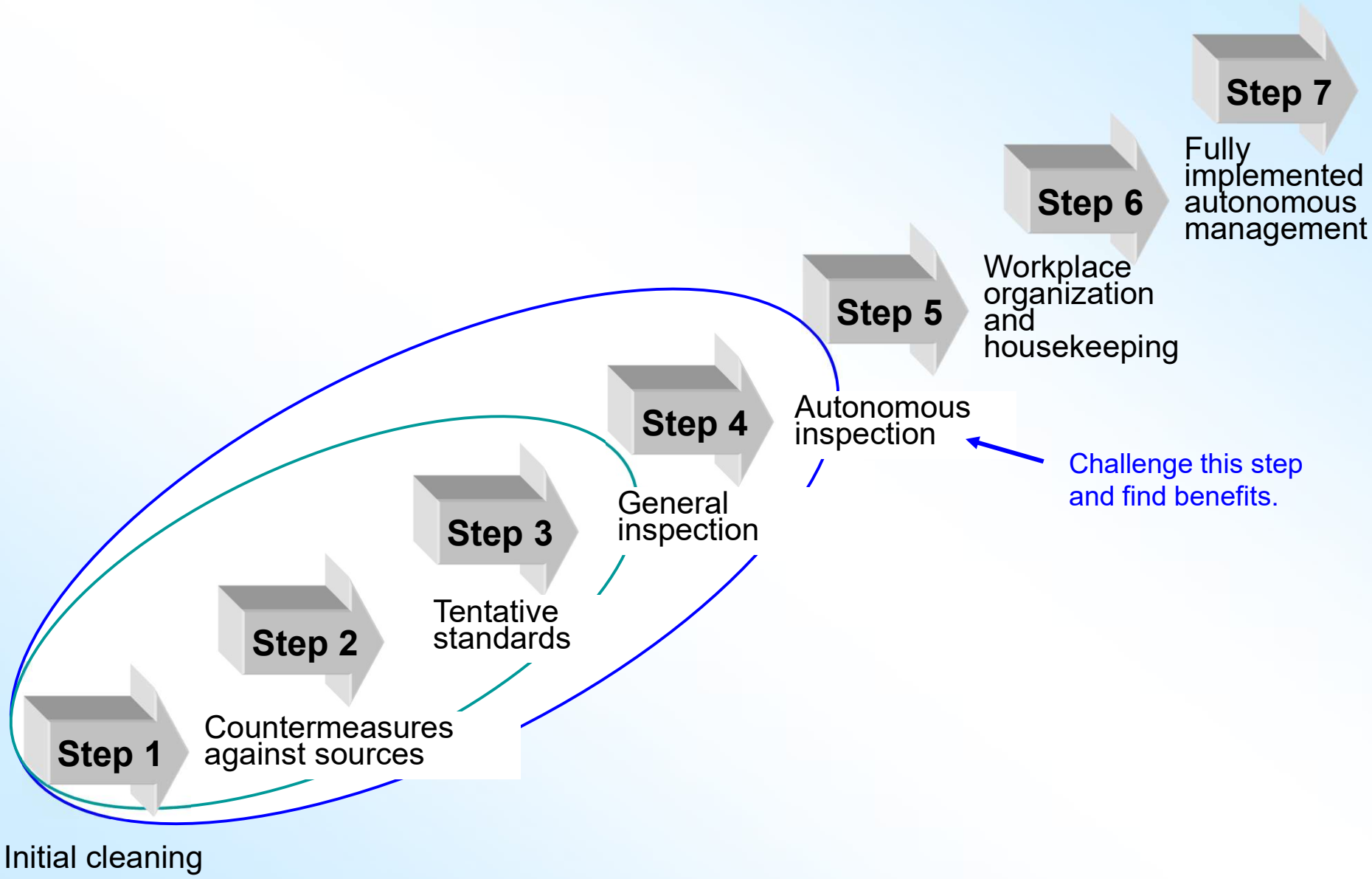
Seven Steps of Focused Improvement



Seven Steps of Quality Control



Seven Steps of Autonomous Maintenance



Action Board for Autonomous Maintenance

1. Team

Leader :

Member :

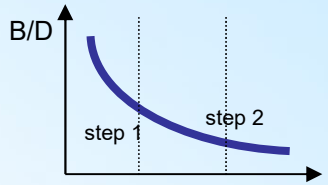
2. Reason for selection

3. Target

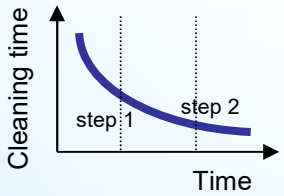
B/D : 1/100

by 31 Jan., 2005

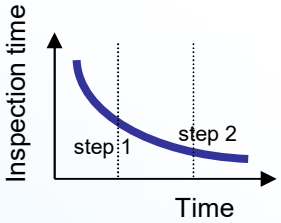
4. 1 Result



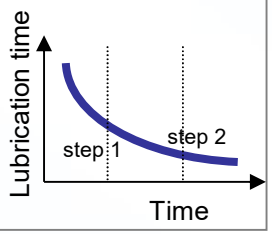
4.2 Result



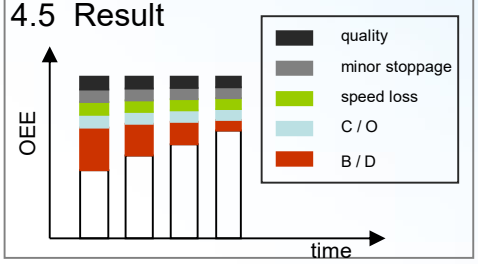
4.3 Result



4. 4 Result

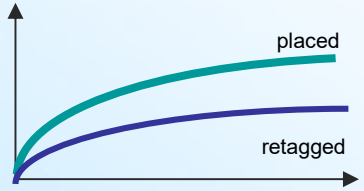


4.5 Result

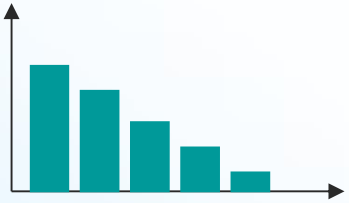


4.6 Cost and benefit analysis

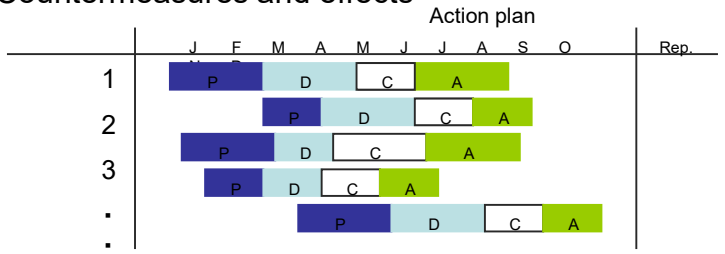
5.1 Tagging



5.2 Analysis of tags



6.1Countermeasures and effects



7.Audit results

- self audit
- group audit
- plant manager audit

Appendix 1

OPL

Appendix 2

- Next action

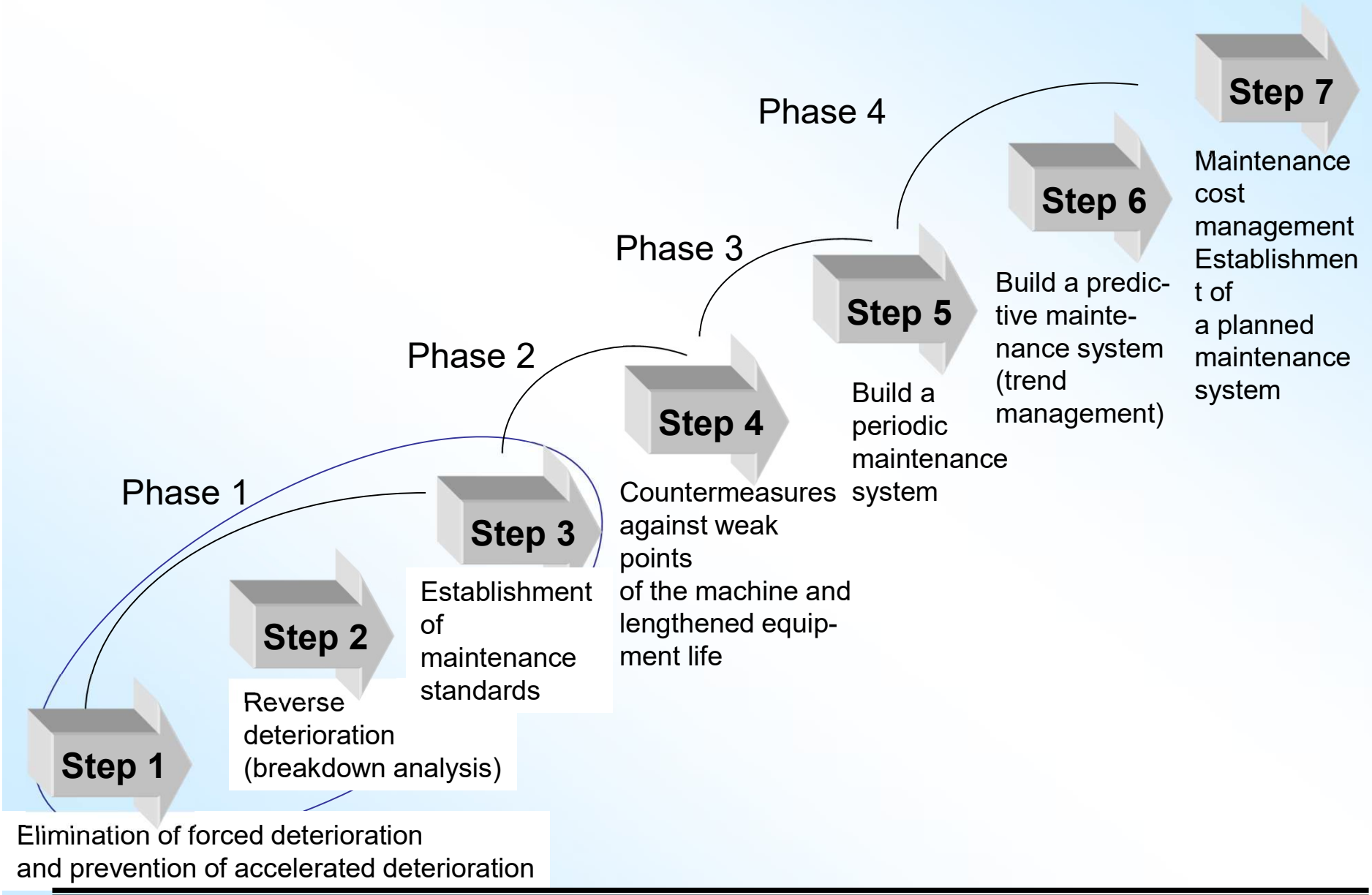
Appendix 3

People development

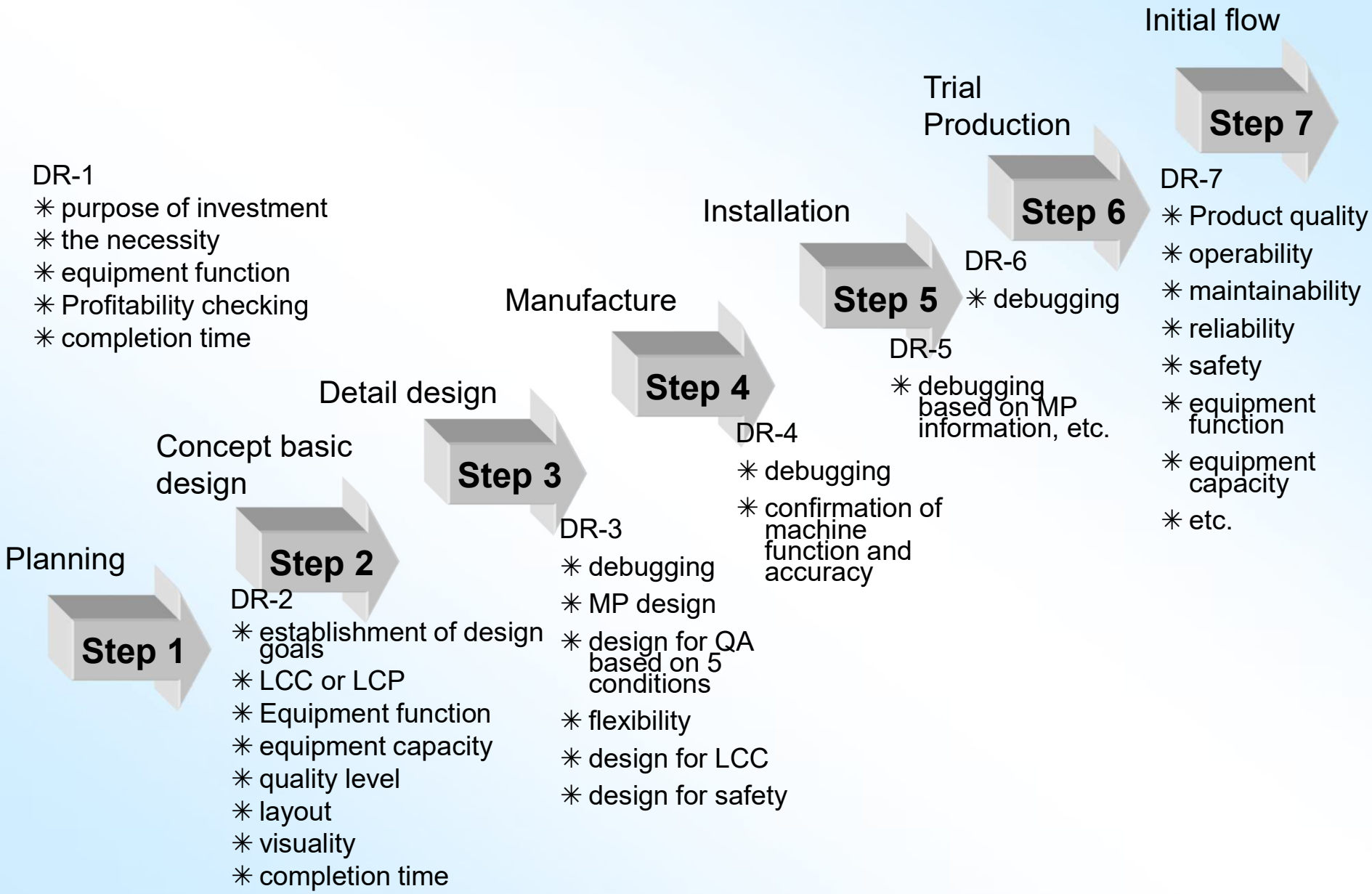
Radar chart

- Team
- Individuals

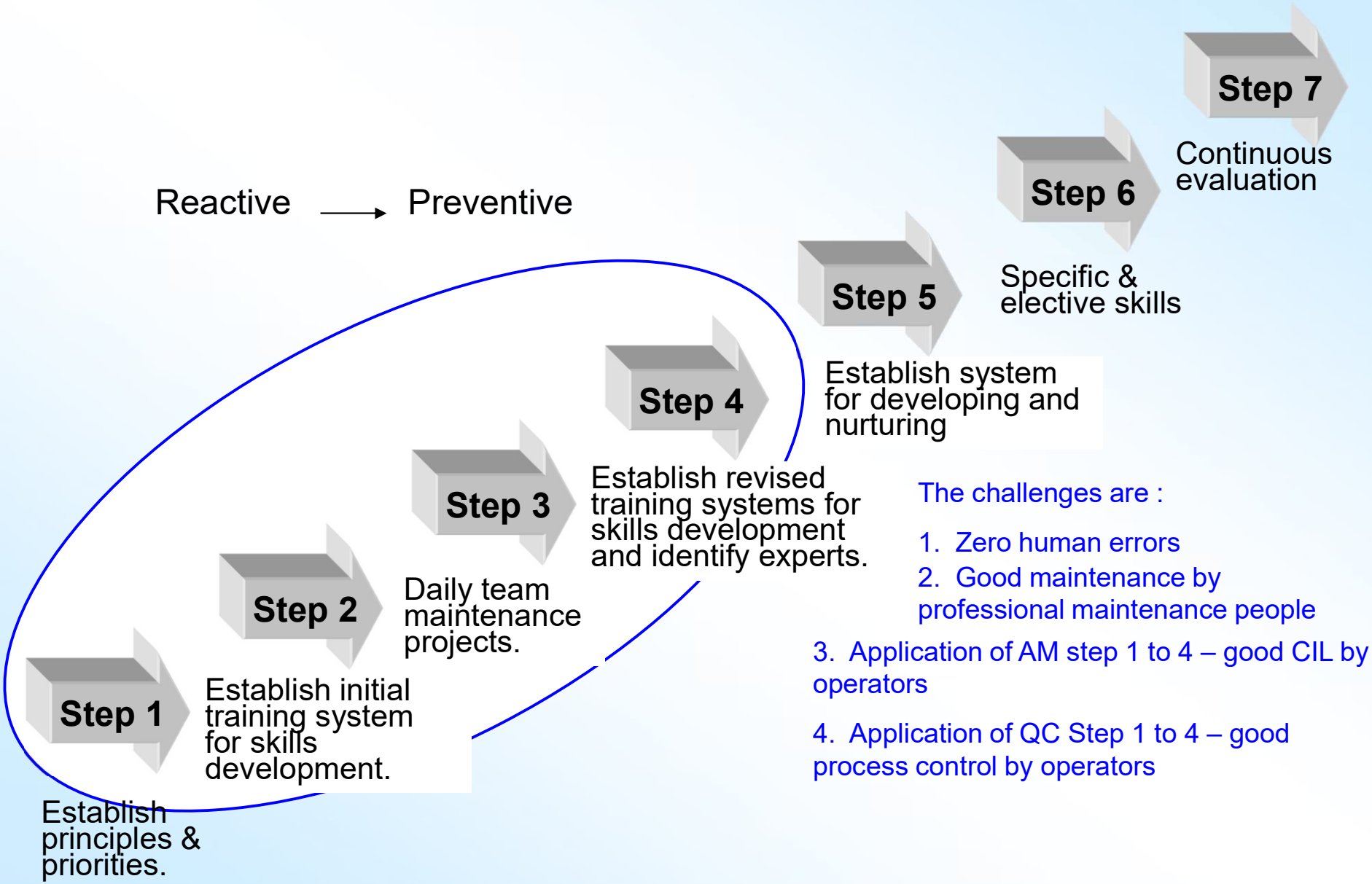
Seven Steps of Professional Maintenance



Seven Steps of E.E.M.



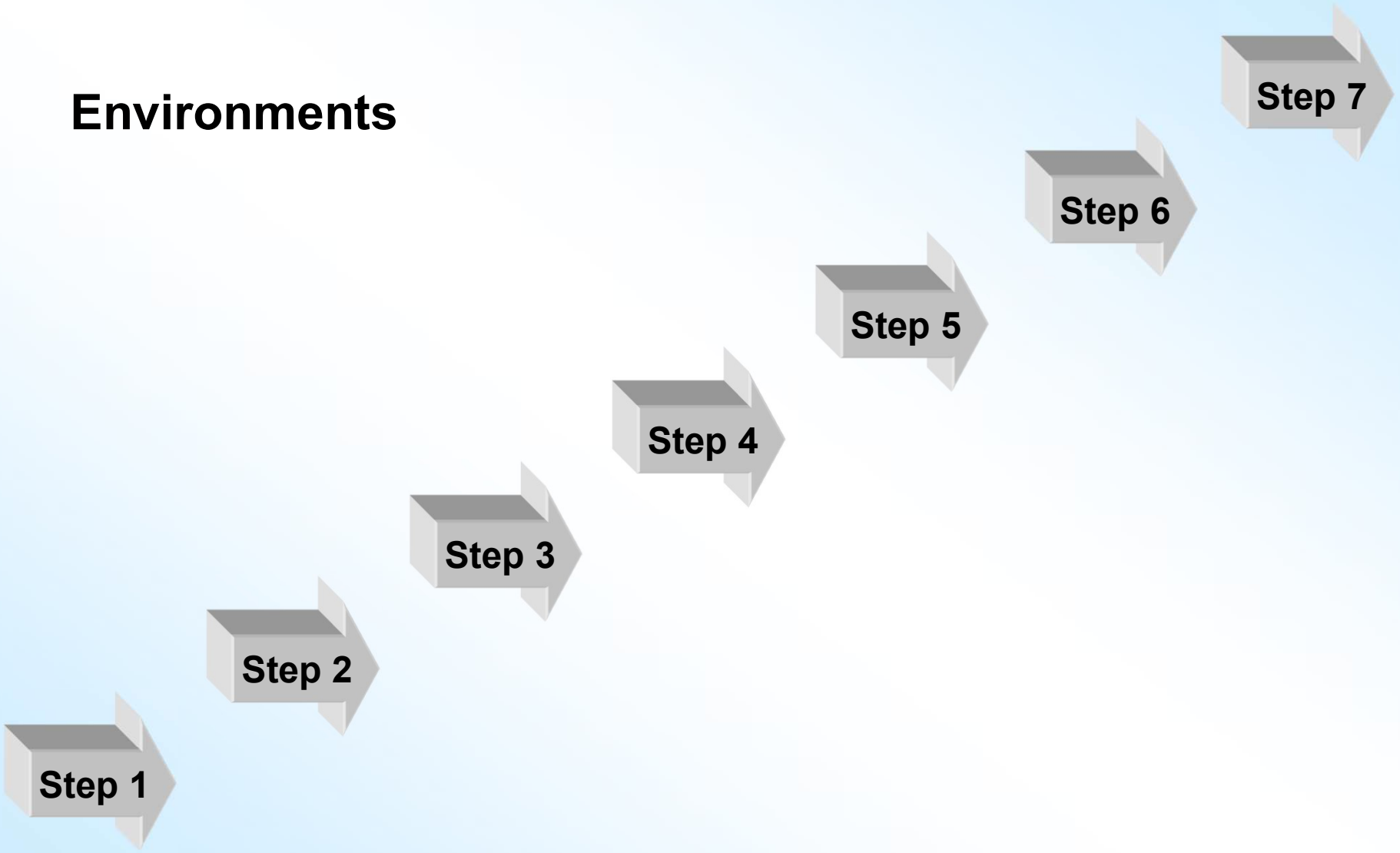
Seven Steps of People Development



The challenges are :

1. Zero human errors
2. Good maintenance by professional maintenance people
3. Application of AM step 1 to 4 – good CIL by operators
4. Application of QC Step 1 to 4 – good process control by operators

Seven Steps of Creating Good Environments



Step 1 :

- Understand the local laws and regulations on environments and their trends.
- Identify the environmental issues the plant must deal with and rank/priotize them.
- Appoint a responsible person for the environments and form an organization including finance for them.
- Establish an education system to nurture employees on environments and risk management.
- Select an area, a block and processes to attack the identified environmental issues.
- Raise projects and programs for major environmental issues and select team members.
- Set the objective and target.

Step 2 :

- Take action against contamination sources
- Identify proper methods and implement countermeasures against the sources of the identified environmental problems.
- Investigate environmental risk and take countermeasures against them.

Step 3 :

- Prepare provisional standards.
- Horizontally expand in other areas the know-how created in Step 2.
- Establish a self auditing system by the top management.

Step 4 :

- Check input materials such as raw materials and energy, etc. to the plant, area, block and processes and identify how they will come out as outputs such as products, scraps, dust, heat, noise, to the processes, block, area and the plant.
- Quantify them and based on their priorities, take countermeasures against the undemanded outputs step by step.
- Chemical substance control.
- Resource saving.
- Energy saving.

Step 5 :

- Establish an EMS together with supporting systems such as environmental accounting system, operating system and reporting system.

Step 6 :

- Establish systems for environmental load reduction, environmental risk reduction and environmental load reduction in logistics.
- Pursue green procurement.

Step 7 :

- Use fully implemented EMS toward the creation of a model plant for environments.

Educational subjects

Level / Subject	Basic	Intermediate	Advanced
CD	*Definitions of waste and losses *Measurement of waste and losses *Translation of waste and losses to costs *Development of C, D and E matrices *Raising projects	*Waste and losses in indirect divisions	*Up to the upstream involving business department, design department, etc. *Profit deployment

(-Continued)

Level / Subject	Basic	Intermediate	Advanced
TQC	*5S's *7QC tools *SQC *PDCA cycle *QC problem solving approach *Systematic diagram *Objective deployment *QC step1~step4 *The 4M technique *The 5W1H technique *Process capability improvement	*QC step5~step6 *Zero human errors *5 conditions for zero defect *New 7 QC tools *Poka-Yoke *DR system	*QC step7 *QFD *7 tools for product planning *7 tools for establishing strategy *Process QFD *FTA *QA network *Policy management *DOE *Taguchi methods

(-Continued)

Level / Subject	Basic	Intermediate	Advanced
TPM	*AM step1~step3 ** Easy cleaning, checking and lubricating *PM step1~step3 **5 Why's analysis **Breakdown analysis *TBM	*AM step4~step6 *Modified AM ** Assembly ** Inspection ** Forklift ** Material handling ** Warehouse *PM step4~step5 *Processing point analysis (principle and operational standard) *High speed camera method *Spare parts management *CBM *EEM	*AM step7 *PM step6~step7 *RCM *Computerized *Maintenance information system *Real time management *Unmanned operation

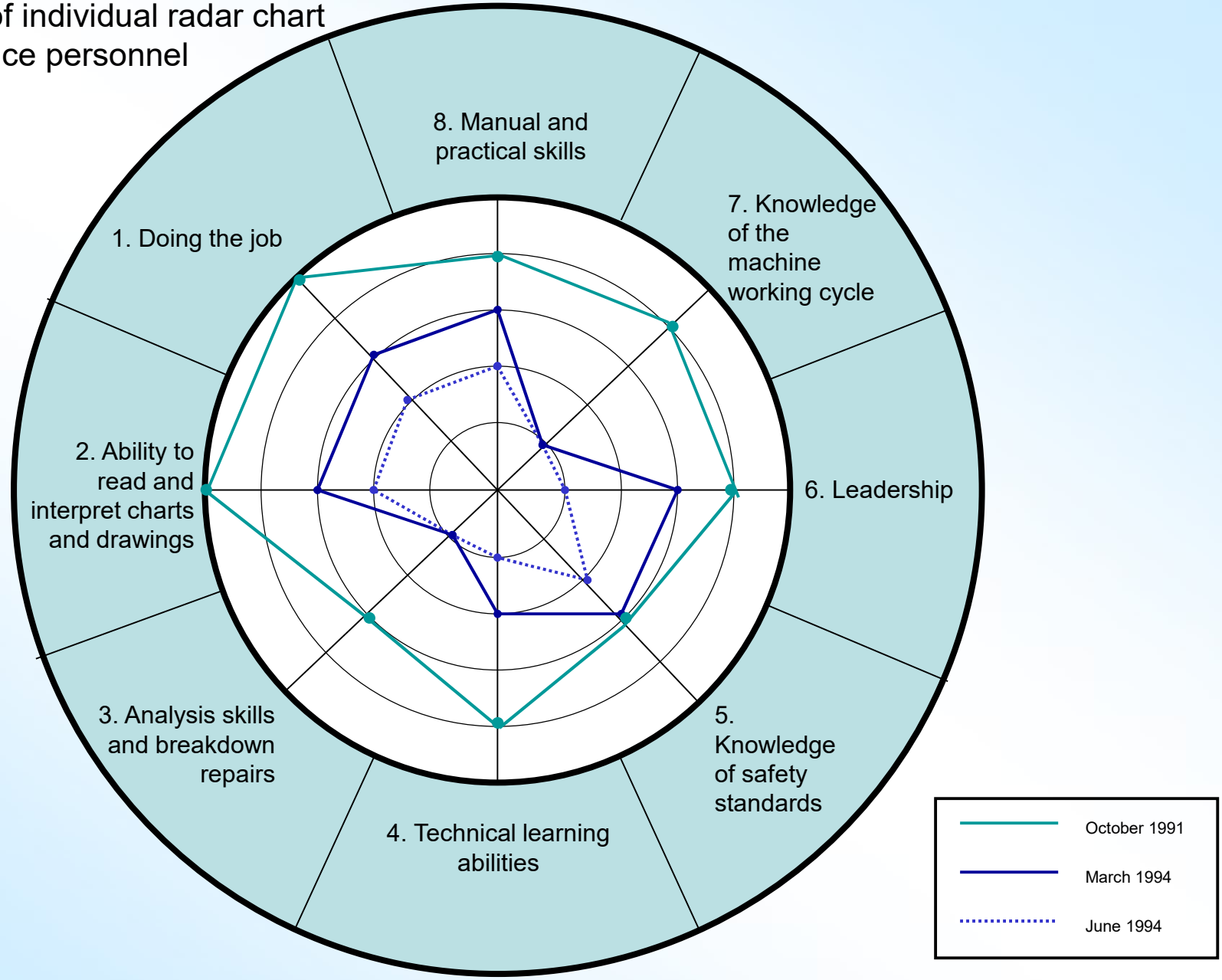
(-Continued)

Level / Subject	Basic	Intermediate	Advanced
JIT	*Production techniques **Minimal M.H. *Setup time reduction techniques **ECRS *Assembly line techniques *Layout techniques *Lead time reduction techniques *Visual management *SOP	*Material management **Sequential feeding **Supply by kanban *Internal logistics *Minimization of transfer batches *External logistics ** Mixed delivery *Flow analysis *Small in-line machines *Inventory management *Integrated logistics of sales, production and distribution	*Production planning and control system *COP *SCM *IPS

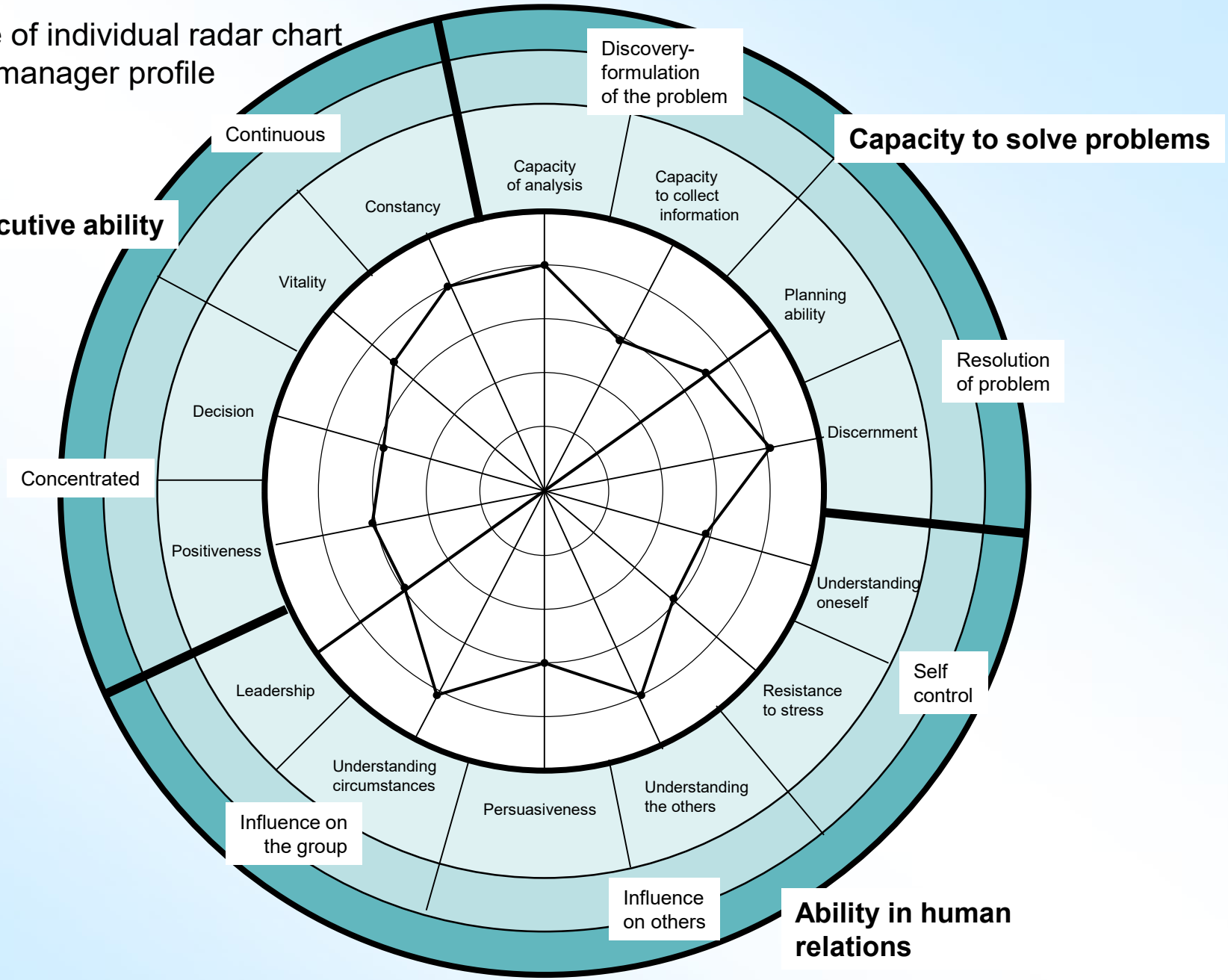
(-Continued)

Level / Subject	Basic	Intermediate	Advanced
TIE	*IE (Muri, Mura, Muda) *Video camera method *Pace monitor *N.V.A.A. *Multi-process operation *Material handling *The way to teach *Radar chart *Skills development *Career path programme *Employee's satisfaction *Safety step1~step3 **Accident analysis	*Safety step4~step6 *Separation of labor from equipment *Separation between the labor of operation and the one of transportation *LCA	*Safety step7 *IE with IT

Example of individual radar chart
Maintenance personnel



Example of individual radar chart
Factory manager profile



Capacity to solve problems	Capacity of analysis	See problems, analyze them, and find the causes and keys to solve them.
	Capacity to collect information	Collect the information that is necessary for solving problems.
	Planning ability	Systematatize processes that are necessary for solving problems and establish concrete procedures.
	Discernment	In order to solve the problems, choose an appropriate countermeasure based on priorities or the degree of importance and implement it.
Ability in human relations	Understanding oneself	Listen to other people's opinions on himself and accept them.
	Resistance to stress	Ability to keep mental stability and proceed with problem solving even under limited time constraints, and pressure from other people.
	Understanding the others	Listen to other people's opinions, understand them and try to be cooperative.
	Persuasiveness	Communicate one's own opinion properly to others and if they have different opinions, try to change them.
	Understanding circumstances	Understand quickly the state of affairs the group is placed in and the psychological development process within the group, and feed them back.
	Leadership	Set objectives or rules of the group, and direct the group by coordinating different opinions among members.
Executive ability	Positiveness	Be the first one to take actions against new problems and new situations.
	Decision	Make a quick and precise decision in spite of some risk even when there is not enough information to make a decision.
	Vitality	In tackling with problems, set the target at a high level and make challenges.
	Constancy	Keep constant and high activity level through the problem solving processes.

An image of a good manager

1. Does the manager regard the problem caused by one of his subordinates as his problem?
2. Does the manager coach his subordinate who caused the problem from the viewpoint of a customer?
3. Does the manager hear from the person directly about the causes of the problem by visiting the spot and examining the real object of the problem?
4. Does the manager discuss about the problem with the person as an engineer?
5. Does the manager praise the person when the analysis and countermeasures of the problem proved efficient and effective?
6. Does the manager talk to his subordinates about how he has grown by making failures and solving them?
7. Does there exist a system which make failure lessons as a knowledge fortune of the company?

(1)Management Commitment

① Not 100% convinced. Only recognizes problems vaguely.

② Is convinced, but doesn't know what to do.

③ Knows what to do and how to do it, but doesn't delegate down into Workgroups / Teams.

④ Delegates to Workgroups / Pillar Teams and follows up by auditing and supporting.

⑤ Masters the WCM system and methods, delegates to Autonomous Workgroups / Teams and controls.

(2) Clearness of the Objectives

① Factory level objectives assessed qualitatively.

② Factory objectives clearly defined quantitatively.

③ Waste and losses are known, translated into money. Factory objectives are consistent with Group objectives. Mechanism in place to track the effect of individual projects on the overall KPIs.

④ Methods to attack various losses are well known, and applied. Good result are achieved.

⑤Continuous searching for waste and losses are made, and appropriate techniques to continuously attack them are established, and applied.

(3) Route Map to WCM

①No proper improvement programme. Ad hoc approach to improvement.

②Based on the factory objectives, a Focused Improvement programme (what, where, why, how and who) has been established.

③Appropriate methods to attack losses, identified by the Focused Improvement programme, have been created step by step and sustained results obtained. The effect of each method has been fully evaluated.

④Horizontal expansion of the knowledge learned has been made.

⑤Based on the factory objectives, the Focused Improvement programme is continuously improved ; factory performance is consistently improving and becoming more visual.

(4) Allocation of Highly Qualified People to Model Areas & Model Machines

①No suitable people have been chosen.

②A good team has been selected to teach specific model area or machine. Cross functional teams established to create know-how.

③Knowledge creation is taking place by the selected people and good results are being obtained. Pillar owners and subcommittee for each pillar established and active, pillar activity boards in place.

④Good knowledge has been gained. Based on this knowledge, a programme is made for horizontal expansion. A training programme to enable horizontal expansion is created and implemented. Autonomous Groups are present in the major areas.

⑤New knowledge and methods have been researched and implemented. Programme supported by highly qualified engineers allocated to areas of highest opportunity.

(5) Commitment of the Organization

①People deny that there are problems, or don't want to see them.

②People admit that there are problems, but find excuses for not being able to solve them.

③People accept that there are problems, but are unable to solve them because they don't know how to attack them.

④People want to see potential problems, and try to visualize them. They attack the problems by learning the appropriate techniques.

⑤People know their problems, methods to solve them, and involve all the levels of the organization to attack them. They are ready to attack any problem, and to change their organization if needed after solving the problem.

(6) Competence of Organization Toward Improvement

①No proper methods are used.

②Only elementary methods have been applied.

③Specific methods, to specific problems have been applied.

④A continuous search for advanced methods and techniques is made, and applied as appropriate. Good knowledge is continuously accumulated.

⑤Standardization of the created knowledge is continuously made, and horizontally expanded to other suitable areas and machines.

(7) Time and Budget

①No time and budget allocated to WCM.

②An annual schedule and budget are made, but not correctly followed.

③An annual schedule and budget determined, and each project is properly followed.

④Correct delegation of authority has been made. Each group autonomously deploys the factory objectives, into their own objectives, and systematically improves their area.

⑤WCM activities are built into annual, monthly, weekly, and daily routine work, and the factory performance is improving in a measurable and visible way. Autonomous work groups are responsible for managing their own activities and budgets.

(8) Level of Detail

①Few aggregate data.

②There is a linkage between problems, analysis, and solutions. There is insufficient detail to identify the reasons as to allow the problems to be rectified.

③There is a logical linkage among problems, analysis and solutions. The clues to resolve the problems are identified.

④”From preventive approach to proactive approach” is taking place.

⑤Very detailed problem identification, detail analysis, and thoughtful and usable proactive solutions. Any abnormality can be easily detected.

(9) Level of Expansion

①Few projects.

②Model areas and model machines to attack major waste and losses.

③Expanded to AA and A class machines.

④Expanded to (A + B) class areas, and (A + B) class machines.

⑤All the necessary areas and machines in the entire factory are covered.

(10) Motivation of operators

①No interest in improvement.

②Interested in improvement, but lack discipline and unable to see problems clearly yet.

③Want to improve, see problems, and learn methods to resolve the problems. All employees across the plant must be involved.

④Want to improve, have proper knowledge, and skills to improve.

⑤Eager to improve, ready to attack any problem, by learning and applying proper method.

Ten Criteria to Evaluate Achievement Level of WCM Pillars at Each Plant

(1) Safety

①There are reports of accidents. No substantial reduction of accidents has been achieved yet.

②Each time an accident takes place, an accident analysis is made and countermeasures to avoid a repeat are taken.

③There are safety standards, but are not strictly followed by all employees.

④People are responsible for their own safety, and take countermeasures autonomously against safety problems.

⑤No Lost Time Accidents for the last three years. Proactive approach to safety. Fully implemented Safety Management System. ISO 18000 achieved.

(2) Customer Service

①There is no system to measure Customer Satisfaction. Only availability and stock level is checked.

②System in place to measure Customer Satisfaction in terms of Q, C and D. Availability is not 100%. No checking of lost Customer orders due to non-availability of stock or inability to manufacture.

③There is a system to measure Customer Satisfaction in terms of Q, C and D. Availability and stock level of each item is checked. There is a procedure to check for lost Customer orders due to non-availability of stock or inability to manufacture. Stock level is above 2 weeks.

④There is a system to synchronize production and sales. The production lead times are a minimum. Thus, availability is close to 100%. Stock level is less than 2 weeks.

⑤Customers are fully satisfied with the products they bought in terms of Q, C and D. Availability 100%. Lost orders are 0. Stock level of less than 1 week.

Note: Q = Quality, C = Cost, D = Delivery

(3) Cost deployment

①No proper understanding, definitions and measurement of waste and losses.

②Waste and losses have been roughly defined and identified. Based on an approximate translation of waste and losses into cost, some projects and activity programmes have been created. There is a lack of co-operation between Finance and Production. The results of improvement activities have not been financially checked .

③All major waste and losses are identified jointly by the co-operation between Finance and Production. Waste and losses are almost correctly translated into cost. Based on the cost deployment, proper projects and programmes are run and good results obtained. Must be implemented to required standards.

④Cost deployment matrices of A, B, C, D and E are correctly used in all the major areas and substantial cost reduction has been achieved.

⑤Whatever improvements have been made, there is a philosophy to continuously seek for opportunities to reduce cost and increase productivity. For this purpose, 30% of the Cost of Conversion is regarded as waste and losses, and efforts are continuously made to try to identify such waste and losses. Each time waste or losses are reduced, the lessons learned are horizontally expanded to other areas.

(4) Focused improvement

①There are no projects or programmes based on Cost Deployment. All the projects are chosen ad hoc, and no systematic approach or a proper method is used.

②There is a system to choose subjects for Focused Improvement but no proper cost and benefit analysis is made. There is no system to horizontally expand the knowledge gained after each Focused Improvement.

③Based on Cost Deployment, proper subjects for Focused Improvement have been selected. Based on the needs of the Focused Improvement, a proper cross-functional team is formed. Knowledge to reduce or eliminate waste and losses are created step by step.

④There is substantial knowledge to eliminate or reduce waste and losses.

⑤There is a system to continuously increase the in-house knowledge to reduce or eliminate all possible waste and losses. The knowledge is horizontally expanded.

(5) Quality Control

①No proper Quality Control is practiced. Based on inspection the good and rejects are sorted out. No measurement of Cp, Cpk.

②Model processes for Quality Control have been chosen, and Step 1 ~ Step 4 have been implemented. The results improve Quality Control giving benefits. Cp, Cpk are measured.

③Step 5 to the model processes. Step 1 ~ Step 4 to A class processes for improving quality.

④Step 6 for model processes. Step 4 to Step 5 for A class processes. Step 1 ~ Step 3 for B class machines. Increased Condition Based Maintenance for the machines.

⑤Step 7 for model processes. Step 6 for A class processes. Step 4 ~ Step 5 for B class processes. For (A + B) class processes, proper maintenance in case of the machine has been chosen.

(6) Autonomous Maintenance

①Model machines for AM have been chosen and Step 1 ~ Step 3 have been implemented to correct standards. A system for auditing that the steps have been correctly followed is in place.

②Step 4 for model machines. Step 1 ~ Step 3 for all AA class machines have been completed. Cost and benefit analysis proves benefit of AM.

③Step 5 for the model machines. Step 1 ~ Step 4 to all AA class machines. Step 1 ~ Step 3 to A class machines.

④Step 6 for model machines. Step 5 for AA class machines. Step 1 ~ Step 4 to (AA + A) class machines.

⑤Step 7 for model machines. Step 6 for AA class machines. Step 1 ~ Step 5 for (AA + A) class machines. Autonomy starts to take place from model machines, gradually A class machines and then up to B class machines.

(7) Professional Maintenance

①Mainly Breakdown Maintenance is practiced. No measurement of MTBF and MTTR of major machines and components.

②Model machines for Professional Maintenance have been chosen and Step 1 ~ Step 3 have been implemented. Mainly Breakdown Maintenance. Steps 1 ~ 3 must be fully implemented and to correct standards. Each step is audited before moving onto the next step.

③Step 4 ~ Step 5 to model machines. Step 1 ~ Step 3 to AA class machines. From Time Based Maintenance to Condition Based Monitoring.

④Step 6 for model machines. Step 5 for AA class machines. Step 1 ~ Step 4 for A class machines for improving quality

⑤Step 7 for model machines. Step 6 for AA class machines. Step 1 ~ Step 5 to A class machines.

(8) EEM

①There is no system to create production and maintenance friendly equipment.

②1st trial of EEM by the introduction of an EEM system. Still substantial modifications are needed. The machine has many design weaknesses.

③Several trials of EEM continuously refining the EEM system. Fewer modifications are needed. The equipment is not perfect but acceptable.

④Good experiences of EEM. Capable to guiding and coaching equipment suppliers. Only some minor problems are left at the time of full.

⑤There is a good EEM system to guarantee Quality, Cost and Delivery. Ease of operation and maintenance. Each time any major investment is made, the EEM system is refined.

(9) People Development

①No system to evaluate required knowledge and skills of each employee, and actual levels of their knowledge and skills.

②There is a rough evaluation system for checking required knowledge and skills of all employees, but no measurement system for checking their actual knowledge and skills. Evaluation system to be applied across entire plant.

③There is an evaluation system for checking required knowledge and skills of all employees, and a measuring system for checking their actual knowledge and skills. Gap analysis is made, but education and training are carried out ad hoc. No financial evaluation of losses due to lack of knowledge and skills.

④There is a systematic education and training system, for minimizing the gap between the required knowledge and skills of each employee, and their actual knowledge and skills. The cost of education, training and the costs caused by lack of knowledge and skills are continuously followed up. There is continuous effort to make education and training as efficient and effective as possible. Employees are willing to make improvements and are highly motivated to take on additional skills.

⑤There is a systematic education and training programme to create competent human resources at every level such that the company can be continuously developed into a World Class one.

(9) Environment

①The management is not well aware of the local laws and regulations on environments and their trends. There is no clear vision on environmental issues and no time and budget allocated for environmental improvement.

②There is a vision on the environmental issues and leadership by the top management toward environmental improvements. The top knows what environmental issues the plant must deal with in long, medium and annual terms and deploy them into action programmes with the necessary budget. There is an appointed person responsible for the environmental improvements and an organization including finance. There exists an education system to nurture employees on environmental issues and risk management.

③All major internal and external environmental issues are clearly identified and visualized as in a noise map, a dust map, risk maps, environmental load maps, etc. Based on the deployments of environmental issues, proper projects and programmes are run and good results obtained. Must be implemented to required standards. An EMS focusing on manufacturing and internal logistics and self auditing system are available.

④All the major areas on environmental issues are managed under the EMS and a substantial improvement has been achieved. Almost no pollution problems exist. There exist supporting systems such as environmental accounting and reporting system. External benchmarking with competitors has been made and the plant managers far better than the competitors. Ready for applying or already got an external certification such as ISO 14000.

⑤There exist well established systems for environmental load reduction, operating system, environment risk reduction and they are all actively working well. There is a philosophy to continuously seek for opportunities for better environments.